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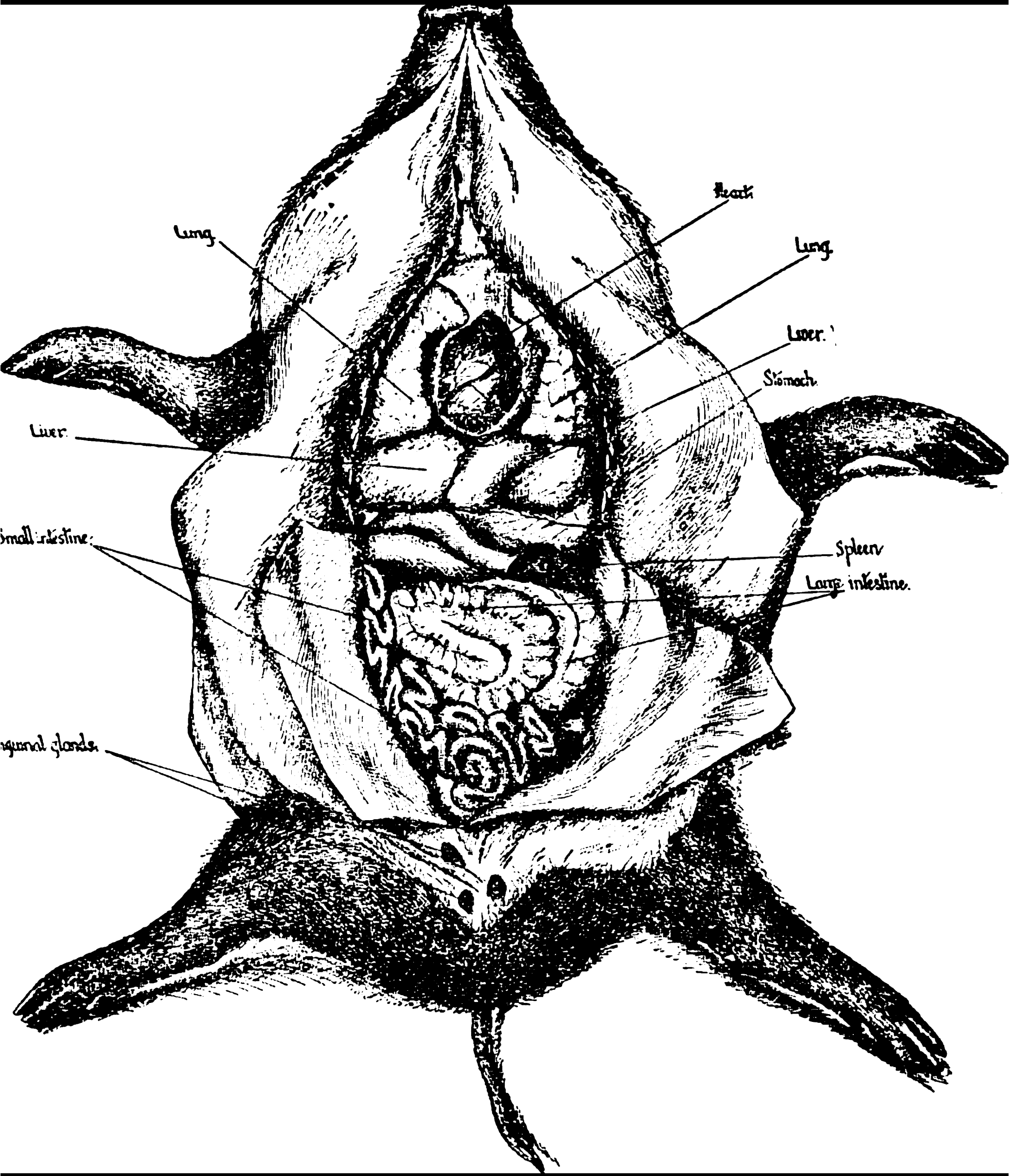

Farmers' Bulletin

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JOSEPH A. ARNOLD,

EDITOR AND CHIEF.

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Issued October 1, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN 376.

GAME LAWS FOR 1909.

A SUMMARY OF THE PROVISIONS RELATING TO SEASONS, SHIPMENTS, SALE, LIMITS, AND LICENSES.

BY

T. S. PALMER, HENRY OLDYS, AND C. E. BREWSTER,
Assistants, Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF BIOLOGICAL SURVEY,
Washington, D. C., September 1, 1909.

SIR: I have the honor to transmit herewith, for publication in the series of Farmers' Bulletins, a summary of the game laws for 1909 relating to seasons, shipment, sale, limits, and licenses, prepared by T. S. Palmer, Henry Oldys, and C. E. Brewster, of the Biological Survey. This bulletin is similar in scope to those issued annually since 1902 and includes changes in the laws made during the present year. The information here given has been revised and the section relating to seasons entirely rewritten to show the open instead of the close seasons. In the section relating to the legislation of the year a brief but comprehensive review is given of the new laws and the more important bills which failed to pass, a feature believed to be of special value to those interested in game protection.

Respectfully,

C. HART MERRIAM,
Chief, Biological Survey.

Hon. JAMES WILSON,
Secretary of Agriculture.

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MAPS SHOWING LICENSE LAWS IN 1909.

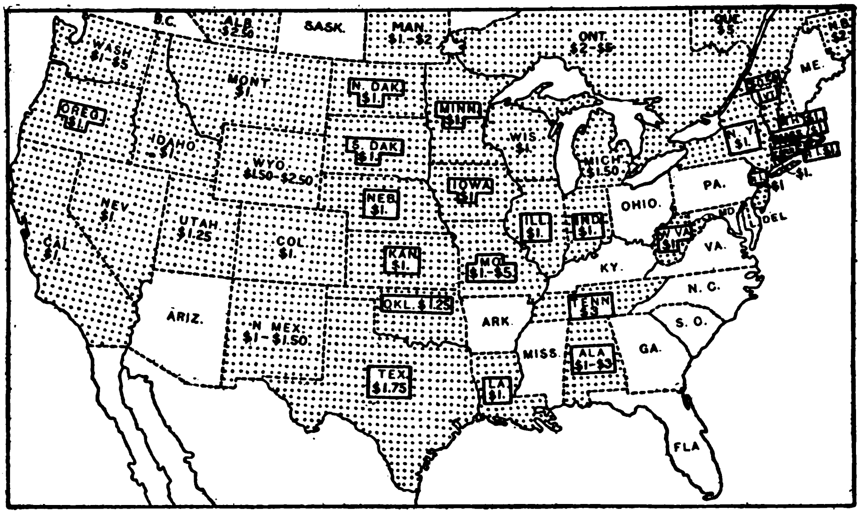

FIG. 1.—States and Provinces which require residents to obtain hunting licenses.

Inclosed names indicate States which permit residents to hunt on their own land without license. Nova Scotia has a $5 resident license and exempts landowners.

Note that many of the States adopt the French method of exempting landowners, while some, particularly in the West, follow the English method of requiring everyone who hunts to obtain a license.

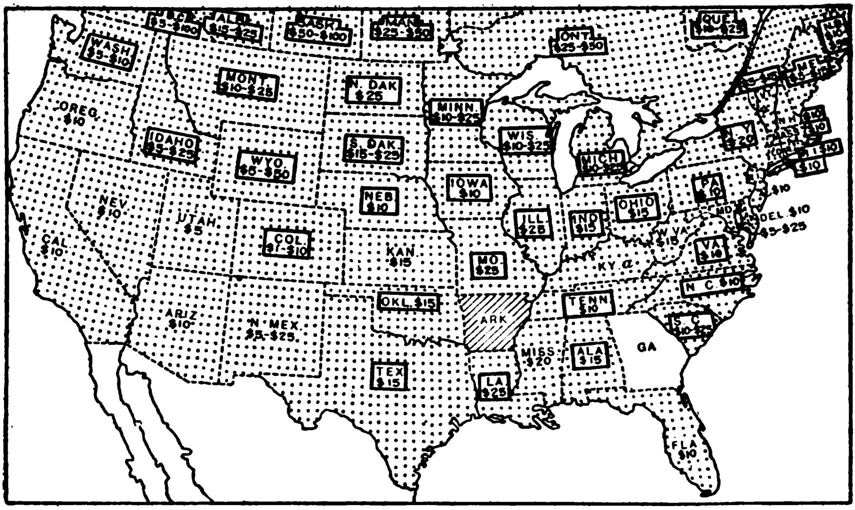

FIG. 2.—States and Provinces which require nonresidents to obtain hunting licenses.

Inclosed names indicate the States which specifically permit licensees to take a limited amount of game out of the State. Alaska and Newfoundland have $50, Nova Scotia $30, and Prince Edward Island $15 nonresident licenses, with export privileges. Arkansas does not permit hunting by nonresidents, except in a few counties. Kentucky, marked *a*, has no definite fee. (For details, see pp. 46-52.)

GAME LAWS FOR 1909.

INTRODUCTION.

SCOPE OF THE BULLETIN.

The present bulletin, containing the tenth annual summary of the game laws of the United States and Canada, has been prepared on the same general plan as those issued each year since 1902. It differs from other publications on the game laws in several important points: (1) Inclusion of a brief but comprehensive review of the measures enacted and also the more important ones which failed, (2) arrangement of provisions by subjects instead of by States, and (3) adoption of a uniform statement and order of the various details to facilitate ready comparison of similar provisions in different States. Its chief objects are to present in convenient form the restrictions on hunting which affect the enforcement of the federal statute regulating interstate commerce in game, and to show the trend and general condition of legislation from year to year. Provisions relating to seasons, shipment, sale, limits, and licenses are included, but those relating to methods of capture, game refuges, enforcement of laws, disposition of fines and fees, and matters of special or local application are omitted. No attempt is made to give the language of the statute or all the legislation in any State. This can be found only by reference to the laws themselves or to the pamphlet editions of the game laws, obtainable in most States from the proper officials.[a] The topics here included are treated as completely as possible; thus all the local seasons fixed by statute have been included and only regulations of county boards of supervisors in three or four States omitted.

With the rapidly growing complexity of regulations, federal, state, and local, in 50 States and Territories, and the constantly increasing number of persons who hunt, the demand for information concerning game laws is widespread. The problem of how to keep the public informed of the numerous yearly changes taxes the ingenuity of officials, and can be solved only by the fullest cooperation on the part of the press, private associations, and individuals.

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[a] A directory of these officers with their addresses is published as Circular No. 70, Biological Survey, U. S. Department of Agriculture, 1909.

LEGISLATION OF 1909.

The game legislation enacted in 1909 was greater and in some respects more important than that of any previous year. Regular legislative sessions were held in all of the States except 7, and special sessions were held in Alabama and Ohio. Game bills were under consideration at all the regular sessions and also at extra sessions in Texas and Washington, but in Georgia, Kansas, and South Carolina all game legislation failed, leaving 38 States which amended their game laws. In Canada game bills were passed in Alberta, British Columbia, Manitoba, New Brunswick, and Nova Scotia, and changes were made through orders in council in two or three other Provinces. The total number of new laws was about 220, nearly half of which were local measures.

List of Game Laws enacted in 1909.[a]

Alabama	0
Arizona	1
Arkansas	7
California	11
Colorado	2
Connecticut	6
Delaware	5
Florida	1
Georgia	0
Idaho	3
Illinois	1
Indiana	2
Iowa	3
Kansas	0
Maine	8
Massachusetts	12
Michigan	3
Minnesota	5
Missouri	1
Montana	5
Nebraska	1
Nevada	2
New Hampshire	9
New Jersey	3
New Mexico	1
New York	1
North Carolina	79
North Dakota	2
Ohio	0
Oklahoma	2
Oregon	1
Pennsylvania	2
Rhode Island	1
South Carolina	0
South Dakota	2
Tennessee	8
Texas	1
Utah	1
Vermont	9
Washington	7
West Virginia	1
Wisconsin	1
Wyoming	5
Alberta	1
British Columbia	1
Manitoba	1
New Brunswick	1
Nova Scotia	1
Total	220

The legislation of the year has encountered unusual difficulties and obstacles. Besides the failure of the game bills in Georgia, Kansas, and South Carolina, in Washington a general game bill and a section of another bill were vetoed by the governor, but at the extra session a general law was finally enacted August 23. In Texas the bill passed at the regular session was vetoed, and a measure passed at the second extra session failed of approval by the governor, but was filed in the office of the secretary of state and became a law without the governor's signature. In California uncertainty was caused by the new deer law, due to the fact that through some mistake the bill signed by the governor was different from the one actually passed by the legislature, but it was nevertheless declared to be the law as the only one which had received executive approval. Somewhat similar confusion regarding the elk statute in Wyoming was caused by the fact that section 25 of the new law closes the season until 1912, while section 26 provides an open season from September 25 to November 30, and section 38 authorizes the holder of an ordinary or special license to kill one elk under each license. The state warden has announced that licenses will be sold this year as usual. In Tennessee the entire game bill was declared unconstitutional on account of certain defects in the title and some of the sections (Acklen *v.* Thompson). In South Dakota a futile attempt was made to invoke the referendum to defeat the game law after passage. In Montana a house joint resolution providing a pension for the widow of a game warden killed by Indians last year, by authorizing her appointment as a regular deputy game warden, was held to be void by the supreme court; and in Oklahoma a section providing for a game protection fund was considered by the attorney-general to be in violation of a provision of the state constitution which prohibits payment of money by state officials except under direct appropriation by the legislature. ("Am. Field," p. 165, Aug. 21, 1909.)

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[a] No legislative sessions were held in Kentucky, Louisiana, Maryland, Mississippi, or Virginia.

New game codes were adopted by Idaho, Missouri, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Pennsylvania, South Dakota, Utah, West Virginia, Wyoming, and Manitoba, and commissions to codify the game laws were provided for in California, Maryland, and New Jersey. Protection of nongame birds was extended by the adoption of the so-called model law in Oklahoma and North Dakota, and by important amendments in California; while in Illinois, New Mexico, Pennsylvania, South Dakota, and West Virginia protection was removed from a number of predaceous birds without proper discrimination between injurious and beneficial species.

Among the notable features of the year's legislation were certain provisions for game refuges and parks; the protection accorded Hungarian partridges in a dozen or more States, rendered necessary by large importations of these birds during the past year; and the rapid increase in popularity of the alien license, shown by the doubling of the number of States adopting this provision. Several novel provisions were adopted, among which were the authorization given to governors, as a result of the severe forest fires of 1908, to suspend the hunting season in time of drought in Maine, Massachusetts, and Vermont, and in New York to prohibit camping, hunting, or fishing on lands in the forest-preserve counties. Equally important were the provisions making state game refuges of all state parks in Massachusetts and all state parks and national forests in Minnesota; acquiring Reelfoot Lake, Tennessee, as a public fishing and hunting preserve; requiring persons in Pennsylvania intending to establish deer parks to drive off wild deer before inclosing their lands; and laws providing for feeding big game during severe winter weather in Colorado and

Wyoming. Mention should be made also of the measures prohibiting the use of silencers in Maine, North Dakota, and Washington; the baiting of waterfowl in Illinois, and the burning of tules in Oregon between March and September, the last as a protection for nesting waterfowl; and a West Virginia provision for a reciprocal license exemption by owners of adjoining lands under written agreement.

Open seasons.—The most notable changes in seasons were several giving added protection to big game and some important species of game birds and a few reopening seasons for deer. Complete protection was given antelope in Montana, Nevada, Oregon, and Wyoming (thus prohibiting killing of antelope everywhere in the United States except in Washington); elk and sheep in Oregon; does in Colorado, Missouri, and Oregon; cow moose in Nova Scotia; grouse and prairie chickens in Missouri and South Dakota; doves in Montana; doves and quail in Nebraska; and sage hens in several counties in Utah. Spring shooting was prohibited in Massachusetts and North Dakota and extended two weeks in Indiana, Nevada, and Oregon, three weeks in Nebraska, and the open season extended from January 1 to March 1 in Idaho. Protection was afforded waterfowl in Oklahoma, black brant in California, geese and brant in Massachusetts, and shore birds in Illinois, New Mexico, and Oregon. A season for shore birds, geese, and brant was opened in spring in Washington. After being closed continuously for several years a short season was opened for deer (bucks only) in New Jersey and Oklahoma and for does in Nevada and Vermont.

Export.—The tendency to increase restrictions on the export of game is shown in the past year's legislation by the action of Iowa, West Virginia, and Wyoming in joining the ranks of States that prohibit all shipment of game from the State. Iowa formerly permitted the export of shore birds and rail, West Virginia of shore birds and waterfowl, and Wyoming of all game birds. Every State west of the Mississippi River now prohibits the export of all its protected game. In the matter of marketing game raised in captivity the trend is toward removing restrictions, and the year's legislation includes the passage of provisions by New York, North Dakota, South Dakota, Washington, and British Columbia extending the privilege of exporting, under suitable restrictions, certain game, chiefly pheasants, reared in confinement.

Sale.—A noticeable increase occurred in legislative restrictions on sale of game. Iowa, South Dakota, and West Virginia adopted measures prohibiting sale of all game throughout the year (Iowa and West Virginia formerly permitted the sale of any game at certain seasons and South Dakota of birds). In New Brunswick measures were passed prohibiting the sale of partridges, limiting the sale of deer to three under license, and licensing dealers in hides of game animals. Illinois prohibited sale of shore birds taken in the State and restricted the privilege of selling imported game in the open season to game legally captured. North Dakota included waterfowl and several species of upland birds in the list of those which can not be sold at any time; Massachusetts, pheasants; and New Hampshire, squirrels. New Hampshire also limited the sale of deer to two a season, and Manitoba further restricted the sale of ducks. On the other hand, North Dakota permitted the sale of hides of big game (formerly prohibited), and Oklahoma of hides, heads, and horns of big game. An important measure adopted by British Columbia authorizes the lieutenant-governor in council to alter or extend sale seasons.

Bag limits.—In most of the States changes were made in bag limits, and in some instances these were materially reduced. As a result of the modification of the deer limit the only States which now have a limit of more than two deer a season for one hunter are: Arizona, Florida, Montana, Louisiana, Mississippi, Oregon, South Carolina, Texas, Washington, and the Province of British Columbia. Alaska, Arkansas, Florida, Georgia, Maryland, North Carolina, and Virginia have no limit on deer. British Columbia reduced its bag limit on caribou, sheep, and goats. The most noteworthy changes in the bag limits on birds were in relation to waterfowl. Montana and New Mexico established a limit of 20 in place of an unrestricted bag, and California, Colorado, Oregon, South Dakota, and Manitoba made reductions in the bag formerly allowed. California and Oregon also curtailed the shore bird bag limit, and West Virginia placed a limit for the first time on ruffed grouse (6 a day) and wild turkeys (2 a day, 6 a season). Illinois adopted an unusual provision allowing boys under 12 only one-half the regular bag limit.

Licenses.—The growing popularity of the license system is shown by the prominent part it occupies in the legislation of the year. All the States except Arkansas and Georgia now license nonresident hunters; three-fourths of the States license residents, and about one-half license aliens. License legislation was enacted for the first time in Nevada, New Mexico, and Oklahoma; resident licenses were established in New Hampshire, Vermont, Rhode Island, New Jersey, West Virginia, Iowa, Oklahoma, Texas, New Mexico, and Nevada, and alien licenses in a dozen or more States. Utah established an alien license of $100, Manitoba reduced its $100 license to $50, and Pennsylvania prohibited aliens from hunting in the State. Nonresident license fees were increased in Delaware from $5 to $10, in Illinois and Missouri from $15 to $25, and the bird license fee of South Dakota from $10 to $15; and resident license fees were raised in Connecticut from $1.10 to $1.25, in Missouri from $2.50 to $5, and in North Dakota from 75 cents to $1. Apparently the only reductions were the lowering of nonresident license fees in Colorado from $25 to $10 and in Utah $10 to $5 and the fees of residents in South Dakota from $2.50 to $1. Manitoba introduced an innovation in the resident license by requiring a $1 bird license of residents of incorporated cities, towns, and villages.

Warden service.—Important changes were made in the warden service by several States. South Dakota established the office of state game commissioner, and North Dakota modified its system by providing a game and fish board of control, consisting of five members, to take charge of all matters relating to the protection of game. The California commission became, by a change of title, the board of fish and game commissioners; the chief officer in Missouri, formerly the state warden, was made game and fish commissioner; and the warden of West Virginia was made forest, game, and fish warden. In New Brunswick the chief game commissioner was replaced by four chief fishery, game, and fire wardens, each in charge of a special district. In the new game bill of Tennessee the commissioner of agriculture was made ex officio state warden, but as the bill was declared unconstitutional the warden service remains as before. In Illinois one additional deputy was authorized for each county, and in Montana seven additional deputies and in New York an assistant chief and five additional game protectors were provided for the State. Under an appropriation made by Congress, which became available on July 1, warden service has been established in Alaska, and four wardens have been appointed by the governor.

The larger funds now available for game protection, chiefly as a result of a license system, have made it possible for several States to develop their departments and to pay increased salaries. Several changes in salaries were made during the year. The new warden in South Dakota receives $1,500, the commissioner of Illinois has been allowed $1,200 extra and his living expenses as superintendent of the game farm, and the salaries of the chief game officials have been raised in Vermont to $1,500, in West Virginia to $1,800, in Idaho and Wisconsin to $2,000, in Missouri to $2,500 and in New York to $6,000.

Preserves.—An important feature of the new laws was the provision made by several States for the establishment of game preserves and game refuges. Massachusetts provided for making game refuges of all state parks; New York made an appropriation for the purchase of a state game farm; Minnesota enacted two bills making all state parks and national forests within its boundaries game refuges; Wyoming established a game preserve in the Big Horn Mountains and memorialized Congress to donate certain lands on the Gros Ventre River; Idaho created a state game refuge on the Payette

River and a small state park, known as "Heyburn Park," on the Coeur d'Alene Indian Reservation; and California modified its law relating to state game refuges and created a new refuge on the Pinnacles National Forest in San Benito County.

As an outcome of the recent troubles at Reelfoot Lake, resulting in disorder and bloodshed, Tennessee has taken steps to acquire the lake and to maintain it permanently as a hunting and fishing preserve for the benefit of the public.

Under existing laws considerable progress was made in establishing game refuges both in the United States and Canada. Twenty-six national bird reservations were created by executive order, making the present number 51. The President has also set aside a small island in Alaska as a breeding ground for moose, and the higher summits of the Olympic Mountains, Washington, which include the summer range of the Roosevelt elk, as the Olympic National Monument. In British Columbia arrangements were completed for the establishment of Goat Mountain Park, and in Ontario steps were taken to establish a park on the international boundary adjoining the Superior National Forest, which, under a recent Minnesota law, is a game refuge. If Ontario carries out this plan the united refuges will form probably the largest moose preserve in existence.

NEW LAWS PASSED IN 1909.

Federal laws.—Two acts: The criminal code, reenacting the provision protecting birds on bird refuges and strengthening sections 3 and 4 of the Lacey Act, to take effect January 1, 1910; and the tariff act containing an increase of 5 per cent on crude and 10 per cent on dressed feathers imported for millinery purposes.

Arizona.—One act: Closing the season for quail, grouse, snipe, and rail on February 1 instead of March 1 (ch. 54).

Arkansas.—Seven acts: Amending the game laws in the following counties—Phillips (p. 190), Bradley and Dallas (p. 427), Stone (p. 584), Clay (p. 758), Calhoun (p. 1114), Chicot (p. 1121), and Mississippi (p. 1131). All of these laws except that for Mississippi County modify the law prohibiting nonresidents from hunting in the State.

California.—Eleven acts: Establishing bird and arbor day (ch. 82); changing the title of the fish commission to fish and game commission (ch. 238); combining the fish commission and game preservation funds (ch. 256); amending the season for deer (ch. 317);[a] amending the game preserve act of 1907 so as to exclude navigable waters and permit hunting and fishing thereon (ch. 318); amending the license law so as to discontinue the use of metal tags for licenses and allowing 10 per cent of the cost to officers (other than fish commissioners) by whom licenses are sold (ch. 389); opening the seasons for quail, plover, snipe, rail, curlew, and shore birds October 1 instead of October 15, closing the season for quail February 1 instead of February 15, protecting black brant and all imported birds, reducing the bag limit on ducks and black brant to 25, and on other birds to 20 per day, prohibiting the use of power boats in hunting ducks (ch. 395); establishing a game refuge in the Pinnacles National Forest (ch. 428); amending the nongame bird law (ch. 617); amending the law relating to the duties and powers of fish commissioners (ch. 424); and a concurrent resolution authorizing the appointment of a committee of 5 to investigate the feasibility of dividing the state into fish and game districts (Res., ch. 40, p. 1341).

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[a] This bill, which made the open season for deer August 1-November 1, failed to become operative, as the bill actually signed by the governor provided for the opening of the season on July 15.

Colorado.—Two acts: One, amending the general game law by increasing the number of deputies from 10 to 20, changing the seasons, protecting does, reducing bag limits and the nonresident license (ch. 167); the other, authorizing the governor to appoint United States forest officers as game and fire wardens without pay (ch. 168).

Connecticut.—Six acts: Placing a bag limit on quail (ch. 95); amending an act concerning fees of sheriffs and constables by repealing the provision allowing peace officers a $20 fee in cases involving violations of the game laws (ch. 110); amending the act concerning wild fowl so as to prohibit hunting with motor boats and certain floating devices (ch. —); fixing a close season for wood ducks (ch. —); amending the deer damage act (ch. —); and extending the open season for rabbits from December 1 to January 15, but allowing only hunting with dogs and ferrets during the extension of the season.

Delaware.—Five acts: Protecting wild ducks (ch. —); prohibiting hunting rabbits with ferrets (ch. —); conferring jurisdiction of offenses against the game laws upon justices of the peace (ch. —); increasing the nonresident license fee to $10 (House Joint Resolution No. —); and protecting Hungarian partridges (ch. —).

Florida.—One act: Relating to the establishment of uninclosed game preserves and establishing a close season on introduced game birds (ch. —).

Georgia.—[Laws not received at the date of publication of this bulletin.]

Idaho.—Three acts: Appropriating $15,000 from the game fund for the purchase of lands in the Coeur d'Alene Indian Reservation for a park to be known as "Heyburn Park" (H. B. No. 186); a general law shortening seasons on big game and codifying existing laws (H. B. 207); and establishing a game refuge on the Payette River (H. B. No. 242).

Illinois.—One act: Amending seasons, prohibiting baiting of ducks, extending protection to all shore birds, authorizing an increase in the salary of the game commissioner, and the appointment of two deputy wardens in each county, modifying the bag limits, altering the provisions governing the killing and selling of deer and cock pheasants raised in captivity, increasing the nonresident license, and repealing the law prohibiting the use of ferrets (p. 236).

Indiana.—Two acts: Protecting imported pheasants and Hungarian partridges for six years and prohibiting hunting on any game preserve stocked with these birds by the commissioner of fisheries and game (ch. 103); and extending the open season for ducks from April 1 to April 15 (ch. 131).

Iowa.—Three acts: Providing for expenses of the game warden (ch. 152), amending the game law (ch. 153), and establishing a resident license (ch. 154).

Maine.—Eight acts: Amending a clerical error relating to the salary of the clerk to the commissioners of inland fisheries and game (ch. 23); relating to the snaring of rabbits (ch. 42); providing a close season for Hungarian partridges (ch. 51); authorizing the governor to prohibit the use of firearms in the forests during droughts (ch. 52); amending the game law (ch. 90); prohibiting the use of silencers (ch. 129); prohibiting the use of power boats in hunting waterfowl (ch. 140); and relating to the payment of damage caused by deer (ch. 253).

Massachusetts.—Twelve acts: Modifying the existing hunting license law by providing a $1 license for nonresidents owning real estate which is assessed at not less than $500 (ch. 262); opening the season for quail, grouse, and woodcock on October 15 instead of October 1 (ch. 272); permitting the sale at any time of the year under permits from the commissioners of fisheries and game of pheasants artificially propagated (ch. 309); permitting residents to hunt without license on their own lands provided such lands are used for agricultural purposes (ch. 325); providing a fine of $50 for the illegal use of a ferret (ch. 328); providing for the establishment of refuges for birds and game on state reservations and parks (ch. 362); amending the law relating to the killing of deer injuring crops (ch. 396); protecting swans throughout the year, and prohibiting spring shooting of ducks, geese, and brant (ch. 421); authorizing the governor to proclaim a close season for game in times of drought (ch. 422); changing the season for rabbits to October 15 to March 1 (ch. 466); and prohibiting spring shooting of shore birds (ch. 508); also a resolve authorizing the commissioners on fisheries and game to obtain plans and estimates as to the cost of lands, buildings, and apparatus for the protection of game and fish.

Michigan.—Three acts: To protect deer kept in private enclosures (No. 167); transferring the supervision of public shooting grounds on Wildfowl Bay to the commissioner of the state land office (No. 241); and completely protecting quail for five years and prairie chickens indefinitely (No. 251).

Minnesota.—Five acts: To prohibit the capture of rabbits with ferrets in any county having a population of over 225,000 inhabitants (ch. 102); making the Minnesota state forest reserve lands and parks and national forests game refuges (ch. 171 and ch. 320); amending section 32 of the game laws of 1905 (ch. 282); and amending the law relating to shooting after dark from motor boats, batteries, or sink boats (ch. 288).

Missouri.—One comprehensive act reenacting the entire game law, modifying the provisions regarding seasons, shipments, sale, licenses, bag limits, etc. (S. B. No. 80.)

Montana.—Five acts: Shortening the season for deer, elk, and sheep to two months, protecting antelope, beaver, and doves throughout the year, shortening the season for grouse and prairie chickens to the month of October, and extending the open season for waterfowl from December 1 to January 1 (ch. 81); authorizing the appointment of seven additional deputy wardens (ch. 87); amending the laws relating to powers and duties of wardens (ch. 104); amending the license law by classing aliens as nonresidents (ch. 130); and authorizing the appointment of the widow of a deputy game warden for a period of four years in recognition of the services rendered by her husband, who was killed by Indians while serving as a deputy warden (H. J. R. No. 13).[a]

Nebraska.—One act: Revising the general game law (ch. —).

Nevada.—Two acts: One establishing a license system with fees of $1 for residents, $10 for nonresidents, and $25 for aliens, establishing a game and fish preservation fund (p. 38); the other, a general act changing seasons, reducing the limits on deer, antelope, and grouse, placing a bag limit on geese and swans, and authorizing boards of supervisors on petition of 50 taxpayers to pass an ordinance protecting any birds for the length of time prayed for in such petition (p. 213).

New Hampshire.—Nine acts: Protecting pheasants and other foreign game birds (ch. —); providing for the registration of resident hunters (ch. —); prohibiting hunting from power boats (ch. —); authorizing the governor to suspend the hunting season in periods of protracted drought; amending the open season for deer; amending the rabbit law; providing for the payment of the salaries and expenses of the game commissoners from the game fund; and two acts amending the non-resident license law.

New Jersey.—Three acts: Opening the season for deer on Wednesdays in November and permitting one buck a season to be killed by each hunter (ch. 187); making the rabbit season uniform through the State (ch. 192); and establishing a resident license (ch. 270).

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[a] The auditor declined to pay this salary and on appeal was sustained by the supreme court of the State (State ex rel. Peyton *v.* Cunningham, 103 Pac, 497).

New Mexico.—One act: Revising the general game law, establishing resident, nonresident, and alien licenses, etc. (ch. 83).

New York.—One act: Amending certain provisions of the forest, fish, and game law by authorizing the governor to prohibit camping, hunting, or fishing on lands in the forest preserve counties during droughts, increasing the protection against forest fires, and providing for the appointment of additional game protectors (ch. 474).

North Carolina.—Seventy-nine acts: All local game laws but two—an act relating to the enforcement of the game law in 52 counties, which provides for the issue of $10 nonresident licenses good only in these counties and the appointment by the board of county commissioners of a chief game warden in each county, who shall receive $2.50 for each license issued, and restricts the nonresident state license issued by the Audubon Society to the counties not covered by the act (ch. 840); and an act exempting parents or children of landowners from the nonresident license requirement (ch. 185).

North Dakota.—Two acts: A comprehensive game law creating a state game and fish board of control, changing the open season, adopting the A. O. U. model law for the protection of nongame birds, prohibiting spring shooting, and protecting shore birds (ch. 128); and prohibiting the use of silencers (ch. 122).

Oklahoma.—Two acts: A general law making provision for seasons, hunting licenses, bag limits, warden service, etc., and prohibiting sale and shipment of game (ch. 29); and a concurrent resolution memorializing Congress for a national law protecting migratory game birds (H. C. R. No. 5, p. 662).

Oregon.—One act: A general statute (containing a title of 1,100 words) revising and codifying the game law, protecting elk, antelope, and sheep, making changes in the seasons, shortening the seasons for deer, quail, grouse, and waterfowl, protecting snipe, and opening a season for doves (ch. 232).

Pennsylvania.—Two acts: A comprehensive act of 32 sections revising and codifying the game law, shortening the seasons for squirrels, rabbits, grouse, and turkeys, changing the quail season, and making numerous amendments (No. 204); and an act forbidding unnaturalized foreign-born residents who have lived in the State more than ten days to hunt or own shotguns or rifles (No. 261).

Rhode Island.—One act: Establishing a resident license (ch. 38).

South Dakota.—Two acts: Revising the list of birds exempt from protection (ch. 55), and a general law amending and codifying the game laws, changing seasons, and establishing the office of state game warden (ch. 240).

Tennessee.—Eight acts: The Langford general game law of 45 sections, amending the present law and making the commissioner of agriculture ex officio state game warden (ch. 519)[a]; providing for the acquirement of Reelfoot Lake (ch. 371); providing a game law for this lake (ch. 463); and making it a common fishery and game preserve of the State (ch. 534); local acts for Lauderdale County (ch. 59); Henry County (ch. 267); Sullivan County (ch. 451); and Dyer County (ch. 555).

Texas.—One act, passed at the second adjourned session: Amending the game commissioner and hunting license act of 1907 by requiring every resident who hunts, except in county of residence or adjoining counties or on his own land, to secure a license at a cost of $1.75, and providing that all fines, licenses, and other fees shall be deposited in the State treasury in a special fund for the payment of salaries and expenses of deputies.

Utah.—One act: A comprehensive law revising and codifying the game law, repealing the provision protecting does, providing a special season for the protection of quail and sage hens in certain counties, reducing the nonresident license, and establishing a $100 alien license (ch. 53).

Vermont.—Nine acts: Authorizing the governor to suspend the hunting season in times of drought (No. 13); defining the powers of game wardens (No. 137); changing the open season for deer in 1908 (No. 145); removing protection from does and prohibiting the hunting of deer at night (No. 146); providing a 50-cent resident hunting license (No. 147); protecting quail for two years and upland plover for six, shortening the season for grouse, woodcock, plover, snipe, rail, and waterfowl (No. 148); prohibiting the hunting of ducks with artificial lights or boats propelled otherwise than by hand (No. 149); protecting English pheasants until 1913 (No. 150); and relating to the salary of the state game commissioner (No. 188).

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[a] This act was declared unconstitutional by the supreme court of Tennessee in Acklen *v.* Thompson.

Washington.—Seven acts: Prohibiting the killing of birds on Lake Washington or within 1 mile of the shore (ch. 54); prohibiting the capture or killing of certain birds in Skagit and Snohomish counties (ch. 172); prohibiting the shipment of certain game birds from islands of San Juan and Island counties (ch. 182); prohibiting the sale of propagated game birds and animals (ch. 197); prohibiting the use of silencers (ch. 249, Criminal Code, sec. 265); and at the extra session a general act amending seasons, fixing bag limits, prohibiting sale of game, and providing that anyone convicted of violating the game laws shall have his license revoked (S. B. 10).

West Virginia.—One act: A comprehensive act revising and amending the game law, providing for resident licenses, etc. (ch. 60).

Wisconsin.—One act: Containing numerous minor amendments to sections 1498 a–d, l, m, n, p, and q of the game law (ch. 525).

Wyoming.—Five acts: Appropriating $5,000 for the purchase of feed for elk and other big game (ch. 59); amending the law relating to nongame birds (ch. 79); and an act of 67 sections, making a number of important changes in the laws relating to seasons, bag limits, licenses, warden service, state preserves, etc. (ch. 163); a memorial requesting Congress to grant certain lands for a winter refuge for big game (H. J. Mem. No. 2); and a memorial requesting the State of Idaho to create a state game preserve contiguous to the Wyoming state game preserve (H. J. Mem. No. 4).

Alberta.—One act: Changing the open season for sheep and goats, protecting Hungarian partridges for two years, and providing a $1 license for export of branded heads (ch. 5).

British Columbia.—One act: Amending the general game act by increasing the nonresident license to $100, changing the bag limits, prohibiting the use of dogs in hunting deer except under permit from the warden, prohibiting the use of automatic guns, and increasing the penalty for violation of the law (ch. 20).

Manitoba.—One act: Limiting the number of big game which can be taken in one year to 1 in all, protecting pheasants until 1920, changing the seasons for grouse and prairie chickens, reducing the alien license from $100 to $50, and providing a $1 resident bird license (ch. 22).

New Brunswick.—One act: Changing the open seasons for big game, upland game birds, and waterfowl, and protecting grouse until 1912 (ch. 46).

Nova Scotia.—One act: Advancing the opening of the moose season two weeks, prohibiting the use of dogs in hunting any game, and shortening the season for rabbits one month (ch. 53).

Ontario.—Orders in council modifying regulations concerning licensed guides and closing the season for partridges until September, 1910.

Yukon.—Order in council restricting licenses to nonresidents hunting big game.

BILLS WHICH FAILED TO PASS.

Measures which fail usually arouse discussion and opposition and frequently occupy much time of the legislature. The circumstances attending their consideration are soon forgotten, but their record is nevertheless important as they comprise bills which are almost certain to be reintroduced until either their passage has been so strongly resisted that they are dropped or the opposition has been overcome and they become laws. It sometimes happens also that in the mass of legislative chaff may be found some grain in the form of novel ideas which, when properly understood and reduced to a practicable basis, are likely to prove valuable. The hunting-license and game-warden laws were in this class only a few years ago and their subsequent popularity may be duplicated at any time by provisions which have as yet failed to receive approval.

Federal bills.—Ten bills affecting game were still on the calendar at the close of the Sixtieth Congress. Two of these provided for the establishment of the Glacier National Park (S. 2032 and 5648); one for the Ozark Mountains Forest Reserve and Game Park in Missouri (H. R. 21487); five for the establishment of game refuges, two in Alaska (S. 7919 and 7920), and one each in California (H. R. 10449), Minnesota (H. R. 13655), and the Olympic Mountains, Washington (H. R. 14037). One measure contained an amendment to the bill authorizing the lease of lands for a buffalo range in Stanley County, S. Dak. (S. 7071), and one general bill provided for federal control of migratory game birds (H. R. 22888). In the closing days of the session an unsuccessful effort was made to secure an appropriation to enable the United States to take part in the International Exposition of the Chase at Vienna in 1910.

The bills introduced in state legislatures are far too numerous to mention in detail, but it is noticeable that a number of them affected the warden system, especially in California, Delaware, Georgia, Illinois, Indiana, Michigan, New Jersey, South Carolina, and Wisconsin.

California.—Unsuccessful efforts were made to provide a salary of $3,000 each for the members of the board of fish and game commissioners, to remove protection from the meadow lark, to prohibit the sale of ducks, and to shorten the duck season.

Connecticut.—Of about 75 bills introduced, comparatively few became laws. Among those which failed were measures to repeal or modify the resident license law, several to permit spring shooting, one to prohibit the sale of game until October 1, 1911 (H. 278), and one to secure statistics of the amount of game killed (H. 418).

Delaware.—Bills to establish a department of game and fish, provide a game commission, and establish a system of resident and nonresident licenses (H. B. 237); and to amend and codify the game law (H. B. 295).

Georgia.—A general bill to provide a state game commission, establish resident and nonresident licenses, and otherwise extend and amend the present game laws.

Idaho.—A bill to provide a game refuge in the eastern part of the State adjoining the game preserve of Wyoming.

Illinois.—Defining the rights of the public on navigable lakes and streams, and permitting fishing and hunting on lakes, streams, and submerged lands (H. 158)—a modification of a similar measure which failed to pass in 1907; providing that citizens of States bordering Illinois may secure nonresident hunters' licenses for the same fee charged residents, provided the same privileges are granted to residents of Illinois (H. 291); a provision (contained in the general game bill, H. 573) protecting wood ducks for four years.

Indiana.—Among 20 bills introduced one proposed to place fisheries, game, forestry, and horticulture under one commissioner, one to make the salary of the game commissioner $3,000, with an allowance of $1,200 for expenses; three to abolish the office of game commissioner (H. B. 5, H. B. 79, S. 406); and three to abolish the fee allowed the commissioner in cases of conviction under the game laws. Three bills were introduced to extend spring shooting of wild fowl and one to prohibit the practice. One measure provided that residents in all the counties except Marion must obtain hunting licenses good only in the township of issue (H. B. 182).

Kansas.—All game legislation, including a comprehensive measure to protect nongame birds.

Maine.—A provision for a system of resident hunting licenses.

Massachusetts.—About 50 bills were introduced, about one-fourth of which became laws. Among those which failed may be mentioned the following: Repealing the resident license law (H. 19, H. 313); establishing a state board of game wardens to enforce the game laws (H. 89); changing the open season for quail from the month of October to the month of November (H. 259); providing an open season of 15 days for deer (H. 312); providing an open season for gulls in Barnstable County (H. 957); authorizing the establishment of state game preserves for periods of 5 to 20 years on private lands embracing not less than 100 acres (H. 587); authorizing hunting on lands under the control of the Metropolitan Water Board (H. 1093); and authorizing employes of said board to kill gulls or other waterfowl on reservoirs of the metropolitan water system (H. 1468).

Michigan.—Of the numerous game bills introduced, 10 were reported out of committee but failed to pass. These included two general game bills changing seasons, two altering seasons for capture of fur-bearing animals, two general hunting license bills, a bill for the better enforcement of the game and fish laws, in which the appointment of 25 additional deputy wardens was provided for, and a bill to create a board of control of the St. Clair flats. This last bill (S. B. 295) provided for the leasing of the state lands frequented by waterfowl on the St. Clair flats by a board consisting of the attorney-general, commissioner of the land office, and auditor-general, authorizing the board to fix rentals for the use of the lands for five years and providing that persons occupying these lands without lease were to be treated as trespassers.

New Hampshire.—Numerous bills, including measures for the better protection of farm and land owners, prohibiting other than property owners from trapping on their land, prohibiting the carrying of firearms by minors under 17 (H. B. 117).

New Jersey.—Numerous bills, including measures to prohibit the hunting of rabbits with ferrets; to prohibit spring shooting in southern New Jersey, providing uniform game seasons for the State, to substitute for the board of fish and game commissioners one commissioner, at a salary of $3,000 per annum (S. 297); establishing game refuges on lands held by the Forest Park Reservation commission (S. 298).

New York.—Numerous bills, chiefly local measures. Among the measures of more general interest may be mentioned the Francis bill prohibiting the sale of plumage (A. No. 65), and the bill repealing the prohibition against spring shooting on Long Island (A. No. 611).

Pennsylvania.—A provision for resident licenses.

Rhode Island.—Bills prohibiting spring shooting (S. 61) and prohibiting the sale of quail, grouse, woodcock, rabbit, and gray squirrel for 3 years (S. 121).

South Carolina.—All game legislation, including measures establishing a state game commission and providing for a system of resident and nonresident licenses, and repealing the provision requiring local nonresident licenses for hunting quail.

Texas.—All general game bills at the regular session, including amendments to the general game law and provisions for resident licenses. The license bill in modified form subsequently passed at the second adjourned session.

Wisconsin.—Numerous measures, including bills permitting spring shooting (A. 158, A. 188, A. 819, A. 834) and hunting water fowl on open waters (A. 379, A. 613); prohibiting use of rifles in hunting deer (A. 703); permitting civil war veterans to hunt without license (A. 635); replacing the office of state fish and game warden by a forest, game, and fish commission (S. 405); and abolishing the office of fish and game warden (A. 198, A. 203, A. 623, S. 405).

OPEN SEASONS.

All the general open seasons for game prescribed by the various States and by the Provinces of Canada are here brought together in one table. For the sake of simplicity a uniform method is used in both the arrangement of species and statement of seasons. In each case deer and other big game are first considered; then rabbits and squirrels; then upland game birds, such as quail, grouse, pheasants, turkeys, and doves; then shore birds; and finally water fowl, such as ducks, geese, and swans. In stating the seasons the plan of the Vermont law, to include the first date but not the last, has been followed consistently.[a] The Vermont scheme has the advantage of showing readily both the open and close seasons, since either may be obtained by reversing the dates of the other.

In some States certain days of the week constitute close seasons throughout the time in which killing is permitted. Hunting on Sunday is prohibited in all of the States and Provinces east of the 105th meridian except Illinois, Louisiana, Michigan, South Carolina, South Dakota, Texas, Wisconsin, and Quebec. Mondays constitute a close season for water fowl in Ohio, and locally in Maryland and North Carolina; and other week days for wild fowl in several favorite ducking grounds in Delaware, Maryland, Virginia, and North Carolina. Hunting is prohibited on election day in Baltimore, Cecil, Frederick, and Harford counties, Maryland; and when snow is on the ground in New Jersey, Delaware, Virginia, and Maryland. The county laws of Maryland and North Carolina, which are too numerous to be included satisfactorily, are not incorporated in the following table, which otherwise may be regarded as a practically complete résumé of the regulations now in force. The difficulty of securing absolute accuracy in a table of this kind is very great, and the absence in the laws of many States of express legislation as to the inclusion or exclusion of the date upon which seasons open and close makes exactness almost an impossibility.

OPEN SEASONS FOR GAME IN THE UNITED STATES AND CANADA, 1909.

[The open seasons include the first date, but not the last. To find the close seasons, *reverse the dates*. Seasons which apply only to special counties are placed to the left of the column containing those for the State in general. Future dates, as Dec. 1, 1912, indicate that the season does not open until that time.]

Alabama (1907):	*Open seasons.*
Male deer (does protected all the year)	Nov. 1-Jan. 1.
Squirrel (black, gray, or fox)	Aug. 1-Jan. 1.[b]
Quail or partridge	Nov. 1-Mar. 1.
Wild turkey gobblers (hens protected all the year)	Dec. 1-Apr. 1.
Ruffed grouse (pheasant), imported pheasant, or other introduced game birds	Dec. 1, 1912.

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[a] See discussion of this question in Circular No. 43 of the Biological Survey, U. S. Department of Agriculture, 1904, entitled "Definitions of the open and close seasons for game."

[b] Also May 15-June 15.

Open seasons for game—Continued.

	Open seasons.
Alabama (1907)—Continued.	
Dove	Aug. 1-Mar. 1.
Plover, snipe	Nov. 1-May 1.
Curlew, sandpiper, woodcock, other shore birds, coot, mud hen, rail, duck, goose, brant, swan	Sept. 1-Mar. 15.
Alaska [a] (1908):	
North of latitude 62°:	
Moose (females and yearlings protected all the year), caribou, sheep	Aug. 1-Dec. 11.
South of latitude 62°:	
Deer	June 1-Dec. 15.
Mountain goat	Apr. 1-Feb. 2.
Moose (females and yearlings protected all the year), caribou (see exception), sheep	Aug. 20-Jan. 1.
Exception: Caribou on the Kenai Peninsula	Aug. 20, 1912
Brown bear	Oct. 1-July 2.
Grouse, ptarmigan, shore birds, waterfowl	Sept. 1-Mar. 2.
Arizona (1905-1909):	
Male deer	Sept. 15.-Dec. 1.
Female deer, spotted fawn, elk, sheep, goat	No open season.
Antelope, 6 years	Mar. 1, 1911.
Quail, bobwhite, partridge, grouse, pheasant, snipe, rail	Oct. 15.-Feb. 1.
Wild turkey	Sept. 15.-Dec. 1.
Introduced pheasant (Chinese, Japanese green, golden, ringneck) 6 years	Mar. 1, 1911.
Arkansas (1901-1907):	
Deer (except in Chicot County, Oct. 1-Feb. 1)	Sept. 1.-Feb. 1.
Squirrel in Lee, Monroe, Phillips, and St. Francis counties	May 1.-Dec. 1
Quail or partridge (except in Bradley and Dallas counties, Nov. 15-Mar. 1)	Nov. 1.-Mar. 1.
Prairie chicken, pinnated grouse	Nov. 1.-Dec. 1.
Wild turkey (except in Chicot County, males, Feb. 1-May 15; hens, 1911)	Sept. 1.-May 1.
Pheasants (Chinese, English), 10 years	Mar. 14, 1913.
Dove	No open season.
California [b] (1901-1909):	
Male deer	July 15.-Nov. 1.
Tree squirrel	Sept. 1.-Jan. 1.
Female deer, fawn, elk, antelope, sheep	No open season.
Valley quail, partridge	Oct. 1.-Feb. 1.
Plover, curlew, shore birds, rail, ibis, duck, black brant	Oct. 1.-Feb. 15.
Mountain quail, grouse, sage hen	Sept. 1, 1911.
Bobwhite, imported quail or partridge, wild turkey, pheasants, swan	No open season.
Dove	July 15.-Oct. 15.
Wilson snipe	Oct. 1.-Apr. 1.
Colorado (1899-1909):	
Deer with horns	Oct. 1.-Oct. 11.
Elk, 15 years	Nov. 1, 1924.
Antelope with horns, 3 years	Sept. 25, 1912.
Sheep with horns, 15 years	Sept. 25, 1924.
Partridge, ptarmigan, wild turkey	No open season.
Quail (bobwhite, crested), 3 years	Oct. 1, 1912.
Pheasant, black game, capercailzie, wild pigeon	Sept. 1, 1914.
Prairie chicken	Oct. 1.-Oct. 21.
Sage chicken, mountain and willow grouse	Sept. 10.-Oct. 11.
Dove	Aug. 20.-Sept. 6.
Plover, curlew, snipe, wading, marsh, and shore birds	Aug. 1.-Dec. 1; Mar. 1.-Apr. 16
Crane, duck, goose, brant, swan, waterfowl	Sept. 10.-Apr. 16.
Connecticut (1901-1909):	
Deer, 10 years	June 1, 1911.
Hare, rabbit	Oct. 1.-Jan. 15.[c]
Gray squirrel	Oct. 1.-Dec. 1.
Quail, ruffed grouse, pheasant (Chinese, Mongolian), woodcock	Oct. 1.-Dec. 1.

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[a] Game animals or birds may be killed at any time for food or clothing by native Indians or Eskimo, or by miners or explorers in need of food, but game so killed can not be shipped or sold.

[b] Seasons fixed by ordinances of boards of county supervisors are omitted.

[c] Between Dec. 1 and Jan. 15 hunting with dog and ferret only.

Open seasons for game—Continued.

	Open seasons.
Connecticut (1901-1909)—Continued.	
Dove	No open season.
Plover, sandpipers, Wilson or English snipe, bay snipe, shore birds, mud hen, gallinule, duck (except wood duck), goose, brant, swan	Sept. 1.-Jan. 1.
Rail	Sept. 12.-Jan. 1.
Wood duck	Sept. 1, 1919.
Delaware (1893-1905):	
Rabbit, squirrel (other than red, in Kent and Newcastle counties)	Nov. 15.-Jan. 1.
Quail, partridge, pheasant	Nov. 15.-Jan. 1.
Dove	No open season.
Reedbird, ortolan, or rail	Sept. 1.-Feb. 2.
Duck (except wood duck), goose, brant, swan	Oct. 1.-Apr. 16.[a]
District of Columbia [b] (1899-1906):	
Deer meat (sale or possession)	Sept. 1.-Jan. 1.
Rabbit (except English rabbit, Belgian hare), squirrel	Nov. 1.-Feb. 1.
Quail or partridge	Nov. 1-Mar. 15.
Ruffed grouse or pheasant (except English, ringneck, or other imported pheasants raised in inclosures, sale or possession unrestricted), wild turkey	Nov. 1-Dec. 26.
Prairie chicken (pinnated grouse)	Sept. 1-Mar. 15.
Dove	No open season.
Plover, snipe, duck, goose, brant	Sept. 1-Apr. 1.
Woodcock	July 1-Jan. 1.
Reedbird, marsh blackbird, rail or ortolan, other game birds	Sept. 1-Feb. 1.
Florida [c] (1903-1909):	
Deer	Nov. 1-Feb. 1.
Quail or partridge, wild turkey	Nov. 1-Mar. 1.
Hungarian partridge, ringneck, and English pheasant, other imported game birds	Nov. 1, 1912.
Duck	Oct. 1-Apr. 1.
Georgia (1905-1908):	
Deer	Sept. 1-Jan. 1.
Quail, partridge, pheasant, wild turkey	Nov. 1-Mar. 15.
Dove, snipe, marsh hen	July 15-Mar. 15.
Woodcock, wood duck, or summer duck	Sept. 1-Feb. 1
Idaho (1909):	
Deer, elk, sheep, goat	Sept. 1-Dec. 1.
Moose, caribou, antelope, buffalo	No open season.
Quail	Nov. 1-Dec. 1.
Grouse	Aug. 15-Dec. 1.
Turtle dove	July 15-Dec. 1.
Sage hen	Aug. 15-Dec. 1.
Prairie chicken, Mongolian pheasant, Canada grouse, or fool hen	No open season.
Plover, snipe, duck, goose, swan	Sept. 1-Mar. 1.
Illinois (1903-1909):	
Deer,[d] 10 years	June 15, 1919.
Squirrel (gray, red, fox, or black)	June 1-Nov. 15.
Quail	Nov. 11-Dec. 10.
Ruffed grouse, prairie chicken, Mexican blue quail, California mountain quail, California valley quail, Hungarian partridge, capercailzie, black grouse, 4 years	July 1, 1911.
Wild turkey, pheasants [d] (copper or Soemmering, English, golden, green Japanese, Mongolian, ringneck, silver, tragopan, Reeves, Elliot, Hungarian, Swinhoe, Amherst, melanotte, impeyan, argus), partridge (black Indian, caccabis, chukar), sand grouse, 6 years	July 1, 1913.
Mourning dove, woodcock	Aug. 2-Nov. 30.

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[a] Wild fowl on Assawaman Bay and tributaries, Sussex County, Nov. 1-May 1 on Tuesdays, Wednesdays, and Fridays.

[b] Hunting prohibited in the District, by act of June 30, 1906, except on the marshes of the Eastern Branch above the Anacostia Bridge, and on the Virginia shore of the Potomac, and no birds can be shot within 200 yards of any bridge or dwelling.

[c] It is unlawful to kill game or game birds within 1 mile of West Palm Beach; similar regulations are in force at St. Augustine. Special seasons: Clay County, quail, wild turkey, Nov. 1-Mar. 1, and 2 days each week rest of year; Hernando County, deer, quail, Dec. 1-Feb. 1; wild turkey, Mar. 1-Apr. 1; dove, duck, Dec. 1-Mar. 1.

[d] Deer raised in inclosure for market may be killed Oct. 1-Feb. 1; cock pheasant, Nov. 1-Feb. 1 under permit.

Open seasons for game—Continued.

Illinois (1903-1909)—Continued.	*Open seasons.*
Golden, upland, or other plover, jacksnipe or Wilson snipe, sand or other snipe, shore birds	Sept. 2-May 1.
Coot, rail, duck, goose, brant, or other waterfowl	Sept. 2-Apr. 15.
Indiana (1905-1909):	
Deer[a]	No open season.
Squirrel	July 1-Oct. 1.[b]
Quail, ruffed grouse	Nov. 10-Jan. 1.
Wild turkey, dove	No open season.
Prairie chicken, Hungarian partridge, pheasant (copper, golden, green, Hungarian, ringneck, silver, tragopan)	Mar. 6, 1915.
Woodcock	July 1-Jan 1.[b]
Duck, goose, brant, or other waterfowl	Sept. 1-Apr. 15.
Iowa (1897-1907):	
Deer, elk	No open season.
Squirrel (gray, timber, or fox)	Sept. 1-Jan. 1.
Quail, ruffed grouse, or pheasant, wild turkey	Nov. 1-Dec. 15.
Prairie chicken (pinnated grouse)	Sept. 1-Dec. 1.
Pheasants (English, Mongolian, Chinese, ringneck)	Oct. 1, 1915.
Turtle dove	No open season.
Plover, sandpiper, marsh or beach birds, rail, duck, goose, brant	Sept. 1-Apr. 15.
Woodcock	July 10-Jan. 1.
Kansas (1903-1908):	
Deer, antelope, 10 years	Jan. 1918.
Red squirrel	No open season.
Quail	Nov. 15-Dec. 15.
Grouse, prairie chicken (see exception)	Sept. 15-Oct. 15.
Exception: Prairie chicken in Butler County, 3 years, to Mar. 9, 1910.	
Pheasants (English, Mongolian, or Chinese), Hungarian partridge, 6 years	Feb. 27, 1913.
Dove	Aug. 1-Sept. 15.
Plover	July 15-Sept. 15.
Duck, goose, brant	Sept. 1-Apr. 15.
Kentucky (1894-1906):	
Deer	Sept. 1-Mar. 1.
Rabbit (except with dogs or snares)	Nov. 15-Sept. 15.
Squirrel (black, gray, or fox)	Nov. 15-Feb. 1.[c]
Quail, partridge, pheasant	Nov. 15-Jan. 1.
Pheasants (English, ringneck, Mongolian, or Chinese)	No open season.
Wild turkey	Sept. 1-Feb. 1.
Dove	Aug. 1-Feb. 1.
Woodcock	June 20-Feb. 1.
Wood duck, teal, or other duck, goose	Aug. 15-Apr. 1.
Louisiana (1904-1908):	
Deer (female and young protected all the year)	Local seasons.[d]
Quail, wood duck	Nov. 1-Mar. 1.
Prairie chicken, woodcock, 2 years	Dec. 1, 1910.
Male wild turkey (female protected all the year)	Nov. 1-Apr. 15.
Dove	Sept. 1-Mar. 1.
Plover, curlew, tatler, coot (poule d'eau), gallinule, rail (mud hen), duck (except wood duck and blue-wing teal), goose, brant	Oct. 1-Mar. 1.
Snipe, sandpiper (chorook and papabotte)	Sept. 1-May 15.
Blue-wing teal	Oct. 1-Apr. 15.
Maine (1903-1909):	
Deer in Aroostook, Franklin, Hancock, Oxford, Penobscot, Piscataquis, Somerset, and Washington counties (see exceptions)	Oct. 1-Dec. 15.
Exceptions: Hancock County, Eden, Mt. Desert, South West Harbor, and Tremont ... Nov. 15-Dec. 15.	
Town of Isle au Haut ... Oct. 1, 1913.	
Swan Island ... Dec. 1-Dec. 8.	
Washington County, Cross and Scotch islands ... July 3, 1919.	

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[a] Deer raised in private preserves may be killed at any time.

[b] Unlawful to hunt any game except waterfowl Oct. 1-Nov. 10.

[c] Also June 15-Sept. 15.

[d] Close seasons for deer in Louisiana, not less than 7 months in length, to be fixed by police juries of the several parishes, but north of latitude 31° the period from May 1 to Aug. 15 to be always included.

Open seasons for game—Continued.

Maine (1903-1909)—Continued.	*Open seasons.*
Deer in Androscoggin County	Oct. 1-Nov. 1.
Deer in Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, Waldo, and York counties (see exceptions)	Nov. 1-Dec. 1.
Exceptions: Knox County, Camden, Rockport, and Hope; Waldo County, Lincolnville, and Searsmont	July 3, 1912
Sagadahoc County, Bath, West Bath, and Phippsburg	No open season
Bull moose with at least two 3-inch prongs on horns	Oct. 15-Dec. 1.
Cow and calf moose	No open season.
Caribou, 6 years	Oct. 15, 1911.
Rabbit	Sept. 1-Apr. 1.
Squirrel (gray and black)	No open season.
Quail, dove	No open season.
Ruffed grouse or partridge, woodcock	Sept. 15-Dec. 1.
Hungarian partridge	July 3, 1913.
Pheasant, black game, capercailzie, 10 years	Apr. 28, 1913.
Plover, snipe, sandpiper	Aug. 1-May 1.
Wood duck, dusky or black duck, teal, gadwall or gray duck, mallard, widgeon or baldpate, shoveler, pintail or sprigtail, redhead, scaup or greater bluebill, lesser scaup or lesser bluebill, golden-eye or whistler, bufflehead, ruddy duck or broadbill (see exceptions)	Sept. 1-Jan. 1.
Exceptions: Golden-eye (Hancock Co.) Nov. 1-Apr. 1. Ducks (Lincoln Co.)	Sept. 1-Feb. 1
All ducks on Merrymeeting Bay, Eastern River, or the Kennebec River below Gardiner and Randolph bridge	Sept. 1-Dec. 1
Maryland[a] (1898-1908):	
Rabbit	Nov. 1-Dec. 24.
Squirrel	Sept. 1-Dec. 1.
Quail, ruffed grouse, wild turkey	Nov. 1-Dec. 24.
Dove	Aug. 15-Dec. 24.
Plover, snipe	Aug. 15-May 1.
Woodcock	Nov. 1-Dec. 24.[b]
Reedbird, sora (water rail or ortolan)	Sept. 1-Nov. 1.
Duck, goose, brant, swan, and other wild fowl	Nov. 1-Apr. 10.
Massachusetts (1902-1909):	
Deer, 2 years	Nov. 1, 1910.
Hare or rabbit	Oct. 15-Mar. 1.
Gray squirrel	Oct. 1, 1910.
Quail, ruffed grouse or partridge, woodcock	Oct. 15-Nov. 15.
Prairie chicken, dove, wild or passenger pigeon, pheasants (English, golden, Mongolian)[c] killdeer or piping plover, swan	No open season.
Heath hen, wood or summer duck, 5 years	Sept. 1, 1911.
Bartramian sandpiper (upland plover)	July 15, 1910.
Plover (except upland and killdeer or piping plover), snipe, sandpiper, peep, rail, gallinule, quark (mud hen), or any shore, marsh, or beach birds	Aug. 1-Jan. 1.
Duck (except wood duck), teal, goose, brant	Sept. 15-Jan. 1.
Michigan[d] (1905-1909):	
Deer (see exceptions)	Nov. 10-Dec. 1.
Exceptions: Deer in red coat and fawn in spotted coat	No open season.
Arenac, Bay, Benzie, Cheboygan, Emmet, and Leelanau counties	1912
Bois Blanc Island (Mackinac County)	1918
Kalkaska County	1910
Elk (see exception), moose, caribou, 8 years	June 16, 1913.
Exception: Elk on Bois Blanc Island	1918
Bear	Nov. 1-Apr. 1.

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[a] The seasons given are the most general. For all seasons under county laws see pp. 53-54, and Poster No. 20, "Open seasons for game, District of Columbia, Maryland, and Virginia, 1909," which may be had upon application to the Biological Survey, U. S. Department of Agriculture, Washington, D. C.

[b] Also July.

[c] Except on private preserves under permit of commissioners on fisheries and game.

[d] On Grand Island, Alger County, native deer, mule deer, blacktail deer, elk, moose, caribou, antelope, buffalo, native partridge, Manitoba grouse, dairipan (European ptarmigan), and ptarmigan are protected to June 7, 1910.

Open seasons for game—Continued.

Michigan (1905-1909)—Continued.	*Open seasons.*
Squirrel (black, fox, or gray)	Oct. 15-Dec. 1.
Quail (Virginia partridge)	Oct. 15, 1914.
Ruffed grouse (partridge), spruce hen (except on Upper Peninsula, Oct. 1-Dec. 1)	Oct. 15-Dec. 1.
Pinnated grouse (prairie chicken)	No open season.
Wild turkey, capercailzie, black game, hazel grouse, pheasants (English, Mongolian), wild pigeon	1910.
European partridge	1912.
Dove	No open season.
Plover, snipe, woodcock, duck, goose, brant, or other waterfowl (except that snipe, bluebill, canvasback, widgeon, redhead, pintail, whistler, spoonbill, butterball, and sawbill duck, goose, and brant may be hunted Mar. 2-Apr. 26, and goose and brant in Chippewa County at any time)	Sept. 1-Jan. 2.
Minnesota (1905-1909):	
Deer, male moose	Nov. 10-Nov. 30.
Elk, female moose, caribou, fawn	No open season.
Quail, partridge, ruffed grouse (pheasant)	Oct. 1-Dec. 1.
Sharp-tailed or white-breasted grouse, prairie chicken (pinnated grouse), turtle dove, upland plover, golden plover, snipe, woodcock	Sept. 7-Nov. 7.
Pheasants (Chinese, English, Mongolian, golden, Reeves, Japanese, tragopan, Temminck)	Jan. 1, 1910.
Duck, goose, brant, or any aquatic fowl	Sept. 7-Dec. 1.
Mississippi (1906):	
Deer (spotted fawn, no open season), bear	Nov. 15-Mar. 1.
Quail or partridge	Nov. 1-Mar. 1.
Wild turkey (females, no open season)	Jan. 1-May 1.
Dove	Aug. 1-Mar. 1.
Plover, tatler, chorook, grosbec, coot (poule d'eau), rail (mud hen), duck, goose, brant, swan	Sept. 1-Mar. 1.
Missouri (1909):	
Deer, males only (no open season for does)	Nov. 1-Jan. 1.
Squirrels (gray, black, fox)	July 1-Dec. 22.
Quail (bobwhite, partridge), wild turkey	Nov. 1-Jan. 1.
Ruffed grouse (pheasant), prairie chicken (pinnated grouse), Mongolian, Chinese, and English pheasants, woodcock, and other game birds, resident, migratory, or imported, not here provided with a season	No open season.
Dove, plover	Sept. 1-Jan. 1.
Snipe, duck, goose, brant	Sept. 15-May 1.
Montana (1905-1909):	
Deer, elk, sheep, goat	Oct. 1-Dec. 1.
Moose, caribou, antelope, bison, or buffalo	No open season.
Quail, Chinese pheasant, Hungarian pheasant, dove	No open season.
Pheasant, partridge, prairie chicken, sage hen, fool hen, grouse	Oct. 1-Nov. 1.
Duck, goose, brant, swan	Sept. 1-Jan. 1.
Nebraska (1901-1909):	
Deer, elk, antelope	No open season.
Squirrel (gray, red, fox, timber)	Oct. 1-Dec. 1.
Quail, partridge, pheasant, ptarmigan, English partridge, Belgian partridge, English pheasant, Chinese pheasant, Mongolian pheasant, English black cock, other imported game birds, wild pigeon, wild turkey, dove, curlew, white crane, swan	No open season.
Prairie chicken, sage chicken, grouse	Oct. 1-Dec. 1.
Plover	July 15-Sept. 1.
Yellow-legs, jacksnipe, Wilson snipe	Sept. 15-May 2.
Crane (except white crane), duck, goose, brant, or any game water fowl	Sept. 15-Apr. 6.
Nevada[a] (1909):	
Deer	Sept. 15-Oct. 15.
Antelope, spotted fawn	No open season.
Mountain quail, grouse	Oct. 1-Jan. 1.
Valley quail	Oct. 15-Jan. 15.
Sage hen	July 15-Oct. 1.
Plover, curlew, snipe, woodcock, sandhill crane, duck, goose, swan	Sept. 15-Mar. 15.

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[a] County commissioners may change dates of close seasons (without altering length) for deer, antelope, or sage hens, or lengthen close seasons for any other game in their respective counties.

Open seasons for game—Continued.

	Open seasons.
New Hampshire[a] (1901-1909):	
Deer in Coos County	Oct. 1-Dec. 1
Deer in Carroll and Grafton counties	Nov. 1-Dec. 15
Deer in rest of State	Dec. 1-Dec. 15
Elk, moose, caribou	No open season.
Hare, rabbit	Oct. 1-Apr. 1.
Gray squirrel	Oct. 1, 1913.
Quail, partridge, ruffed grouse, woodcock, Wilson snipe	Oct. 1-Dec. 1.
Dove, pheasant, any introduced foreign game bird	No open season.
Killdeer, upland plover or Bartramian sandpiper, wood duck	Mar. 7, 1912.
Plover (except killdeer and upland plover), sandpiper, yellowlegs, rail, duck (except wood duck and sheldrake) ("beach birds," coot, teal, may be shot in Rockingham County July 15-Feb. 1)	Oct. 1-Feb. 1.
New Jersey (1903-1909):	
Deer, males only[b] (no open season for does)	Nov. 3, 10, 17, 24.
Squirrel—northern section[c]	Oct. 15-Dec. 2.
Squirrel—southern section, rabbit	Nov. 15-Jan. 1.
Quail, ruffed grouse (partridge), prairie chicken, English (ring-neck) pheasant,[d] wild turkey, woodcock—northern section[c]	Oct. 15-Dec. 2.
Quail, ruffed grouse (partridge), prairie chicken, English (ring-neck) pheasant,[d] wild turkey, woodcock—southern section	Nov. 15-Jan. 1.
Dove	No open season.
Upland plover	Aug. 1-Oct. 1.
Plover (except upland plover), curlew, surf (bay) snipe, sandpiper, yellowlegs, all shore birds	May 1-Jan. 1.
English (Wilson) snipe (bog or jack snipe)	Sept. 1-Jan. 1.[e]
Reedbird, marsh hen, rail	Sept. 1-Jan. 1.
Duck, goose, brant, swan, or other wildfowl—northern section[c]	Oct. 15-Jan. 2.
Duck, swan—southern section	Nov. 1-Mar. 16.
Goose, brant—southern section	Nov. 1-Mar. 26.
New Mexico (1909):	
Deer (with horns)	Oct. 15-Nov. 16.
Deer (without horns), elk, sheep	No open season.
Antelope, 5 years	Mar. 18, 1914.
Quail (native, crested, Messina, California, or helmet), grouse	Oct. 1-Jan. 1.
Bobwhite quail, pheasant, wild pigeon, 5 years	Mar. 18, 1914.
Prairie chicken	Sept. 1, 1915.
Ptarmigan (white grouse)	No open season.
Wild turkey	Nov. 1-Jan. 1.
Turtle dove	Aug. 1-Nov. 1.
Plover, curlew, snipe	Sept. 15-Mar. 2.
New York (1908-1909):	
Deer—Adirondack region[f] and Dutchess County (except bucks, Sept. 16-Nov. 16)	Sept. 16-Nov. 1.
Deer—rest of State (see exception)	No open season.
Exception: Towns of Cochecton, Tusten, Highland, Lumberland, Forestburg, and Bethel in Sullivan County, and Deer Park in Orange County	Oct. 16-Nov. 1
Fawns, elk, moose, caribou, antelope	No open season.
Hare, rabbit	Oct. 1-Feb. 16.
Squirrel, black or gray (except in Richmond and Steuben counties, no open season)	Oct. 1-Dec. 1.
Quail (see exception)	Nov. 1-Dec. 1.
Exception: Dutchess, Putnam, Richmond, Rockland, and Westchester counties, 2 years	1910

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[a] Governor and council may suspend open season in time of excessive drought.

[b] Not applicable to deer in game preserves or to possession of imported deer properly tagged.

[c] The northern section comprises the counties of Bergen, Essex, Hudson, Hunterdon, Morris, Passaic, Somerset, Sussex, Union, and Warren; the southern section comprises the remaining counties.

[d] English or ringneck pheasants in established game preserves may be shot Oct. 1-Jan. 1 by the owners of such preserves or such persons as they may designate.

[e] Also March and April.

[f] The Adirondack region comprises the counties of Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Saratoga, Saint Lawrence, Warren, and Washington, and that part of Jefferson, Lewis, and Oneida counties lying east of the Utica and Black River R. R. from Utica to Ogdensburg.

Open seasons for game—Continued.

		Open seasons.
New York (1908-1909)—Continued.		
Partridge (grouse), woodcock (see exceptions)		Oct. 1-Dec. 1.
Exceptions: Grouse in Putnam, Rockland, and Westchester counties	1910	
Hungarian partridge (European gray-legged partridge), pheasants (Mongolian ringneck, English, and others), 2 years (see exceptions)		No open season.
Exceptions: Ringneck and English pheasants in Dutchess county	Nov. 1-Jan. 1	
Fulton County	Sept. 16-Dec. 1	
Livingston, Monroe, Ontario, Orleans, and Wayne counties (male pheasants may be killed Thursdays and Saturdays in October).		
Dove, wood duck		No open season.
Surf bird, plover, curlew, yellow-legs Wilson or English snipe, jacksnipe, bay snipe, shore birds, water chicken, mud hen, gallinule, rail, duck, goose, brant, swan		Sept. 16-Jan. 1.
Long Island (1908):		
Deer		Nov. 3, 5, 10, 12.
Hare, rabbit, squirrel (black or gray)		Nov. 1-Jan. 1.
Quail, grouse, woodcock (see exceptions)		Nov. 1-Jan. 1
Exceptions: Quail on Robbins and Gardiners islands	Oct. 15-Feb. 1	
Woodcock on Robbins and Gardiners islands	Aug. 1-Jan. 1	
Pheasants (English, Mongolian, ringneck) in Suffolk County	Nov. 1-Jan. 1	
Dove		No open season.
Plover, ringneck, killdeer, oxeye, curlew, willet, yellowlegs, winter snipe, Wilson or English snipe, jacksnipe, surfsnipe		July 16-Jan. 1.
Meadow hen, mud hen, gallinule		Aug. 16-Jan. 1.
Duck, goose, swan		Oct. 1-Jan. 1.
Brant		Oct. 1-May 1.
North Carolina[a] (1905-1909):		
Deer		Oct. 1-Feb. 1.
Quail, wild turkey, dove, lark, robin		Nov. 1-Mar. 1.
North Dakota (1909):		
Deer		Nov. 10-Dec. 1.
Antelope, 11 years		Jan. 1, 1920.
Quail, English pheasant, Chinese ringneck pheasant, Hungarian partridge		No open season.
Ruffed grouse, prairie chicken (pinnated grouse), sharp-tailed (white-breasted) grouse, dove, golden plover, upland plover, snipe, woodcock		Sept. 7-Nov. 2.
Crane, duck, goose, brant, swan		Sept. 7-Dec. 16.
Ohio (1900-1908):		
Rabbit		Nov. 15-Dec. 5.
Squirrel		Oct. 1-Oct. 31.
Raccoon		Nov. 1-Mar. 2.
Quail		Nov. 15-Dec. 5.
Ruffed grouse, introduced pheasants, 5 years		Nov. 15, 1913.
Dove, woodcock		Sept. 1-Dec. 5.
Plover, snipe, shore birds, coot or mud hen, rail, duck, goose, swan		Sept. 1-Jan. 1.[b]
Oklahoma (1909):		
Deer (males only—no open season for does)		Nov. 1-Dec. 1.
Antelope		Nov. 1, 1914.
Quail, Mexican (blue) quail		Nov. 15-Feb. 1.
Prairie chicken		Sept. 1-Nov. 1.
Mongolian, Chinese, English, ringneck, or other pheasant		Nov. 1, 1914.
Wild turkey		Nov. 15-Jan. 1.
Wild turkey (gobblers only)		Mar. 15-Apr. 15.
Plover, curlew, snipe, or other shore bird, crane, duck, goose, brant, swan		Aug. 15-May 1.
Oregon (1909):		
Male deer (except in Baker, Grant, Harney, Malheur, Umatilla, Union, and Wallowa counties, Sept. 15-Nov. 1)		Aug. 1-Nov. 1.
Female deer and spotted fawn, antelope, sheep		No open season.
Elk		Aug. 1, 1919.
Silver gray squirrel		Oct. 1-Jan. 1.
Quail (see exceptions)		Oct. 15-Nov. 15.
Exceptions: Josephine and Jackson counties	Oct. 15-Dec. 15	
Gilliam, Grant, Harney, Malheur, Morrow, Umatilla, and Wheeler counties	Oct. 15, 1913	

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[a] For seasons under county laws see pp. 55-56.

[b] Also Mar. 1-Apr. 21; Sundays and Mondays are closed seasons for ducks and other waterfowl.

Open seasons for game—Continued.

		Open seasons.
Oregon (1909)—Continued.		
Grouse, native pheasant, ruffed grouse, partridge (see exception)		Oct. 15-Nov. 15.
Exception: Baker, Grant, Umatilla, Union, and Wallowa counties.	No open season	
Sage hen		Aug. 1-Nov. 1.
Chinese (torquatus) pheasant cock (see exceptions)		Oct. 15-Nov. 15.
Exceptions: Jackson, Josephine, Hood River, and Malheur counties.	No open season	
Gilliam, Grant, Harney, Malheur, Morrow, Umatilla, and Wheeler counties	Oct. 15, 1913	
Chinese (torquatus) pheasant hen, silver pheasant, golden pheasant, copper pheasant, green Japanese pheasant, Reeves pheasant, English partridge, Hungarian partridge, bobwhite, prairie chicken (except in Grant, Harney, and Umatilla counties, no open season)		Sept. 1-Oct. 15.
Dove, wild pigeon		Sept. 15-Jan. 1.
Turnstone, surf bird, plover, killdeer, curlew, tatler, willet, sandpiper, snipe, stilt, avocet, phalarope, other shore birds, coot, rail		Oct. 1-Mar. 1.
Duck (see exceptions)		Oct. 15-Feb. 15.
Exceptions: Clatsop, Columbia, and Multnomah counties	Sept. 1-Jan. 15	
Baker, Grant, Harney, Malheur, Morrow, Umatilla, Union, and Wallowa counties	Sept. 1-Apr. 1	
Coos, Curry, and Lake counties	Sept. 15-Mar. 15	
Klamath County	Sept. 1-Feb. 1	
Goose,[a] swan, (see exceptions)		Oct. 1-Mar. 1.
Exceptions: Goose (other than Canadian or honker), swan, in Baker, Gilliam, Grant, Harney, Klamath, Lake, Malheur, Sherman, Union, and Wallowa counties	Sept. 1-Apr. 1	
Canadian or honker goose in Grant, Harney, and Malheur counties,	Sept. 1-Mar. 1	
Pennsylvania (1909):		
Deer (deer without horns protected all the year)		Nov. 15-Dec. 1.
Bear		Oct. 1-Jan. 1.
Hare, rabbit		Nov. 1-Dec. 15.
Squirrel (gray, black, fox)		Oct. 15-Dec. 1.
Quail, wild turkey		Oct. 15-Nov. 15.
Ruffed grouse, imported pheasants (Chinese, English, Mongolian)		Oct. 15-Dec. 1.
Hungarian partridge		May 1, 1911.
Dove, blackbird, reedbird, coot or mud hen, rail, sandpiper, tatler, curlew, or any shore bird		Sept. 1-Jan. 1.
Woodcock		Oct. 1-Dec. 1.
Upland or grass plover		July 15-Dec. 1.
Wilson snipe (jacksnipe)		Sept. 1-May 1.
Wild waterfowl—Duck, goose, brant, swan, loon, grebe		Sept. 1-Apr. 10.
Rhode Island (1900-1908):		
Deer[b]		No open season.
Gray squirrel, hare, rabbit		Nov. 1-Jan. 1.
Quail or bobwhite, ruffed grouse or partridge, woodcock		Nov. 1—Jan. 1.
Pheasant, 5 years		Oct. 15, 1910.
Dove		No open season.
Plover, yellow-legs, peep, snipe, shore marsh, and beach birds		Aug. 1-Jan. 1.
Black duck and wood duck		Aug. 15-Apr. 1.
South Carolina (1902-1908):		
Deer (see exception)		Sept. 1-Jan. 1.
Exception: Beaufort, Berkeley, Charleston, Clarendon, Colleton, Darlington, Dorchester, Florence, Hampton, Horry, Kershaw, Marion, and Marlboro counties	Aug. 1-Feb. 1	
Quail, partridge, pheasant, wild turkey, woodcock (see exception)		Nov. 15-Mar. 1.
Exception: Aiken, Barnwell, Beaufort, Berkeley, Charleston, Clarendon, Colleton, Dorchester, Fairfield, Georgetown, Hampton, Kershaw, Oconee, and Saluda counties	Nov. 1-Apr. 1	
Mongolian pheasant, 4 years		Jan. 1, 1912.

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[a] Unlawful to kill geese at any time on islands or sand bars in the Columbia River east of the Cascades.

[b] Tame deer kept in confinement may be killed by the owner at any time, or any deer injuring crops, by the owner or occupant of the premises under permit from secretary of state.

Open seasons for game—Continued.

	Open seasons.
South Dakota (1909):	
Deer, elk, buffalo, sheep	Nov. 1-Dec. 1.
Antelope, 10 years	Jan. 1, 1911.
Grouse, prairie chicken	Sept. 10, 1911.
Partridge, golden plover, upland plover, snipe, woodcock	Sept. 10-Oct. 10.
Dove, English and ringneck pheasant	No open season.
Duck, goose, brant, any aquatic fowl	Sept. 10-Apr. 10.
Tennessee [a] (1903-1907):	
Deer (except Fentress County, Jan. 1-Dec. 1)	Oct. 1, 1911.
Squirrel	June 1-Mar. 1.[b]
Quail or partridge	Nov. 15-Mar. 1.
Grouse, pheasant (except English or ringneck pheasants), wild turkey,[c] meadowlark	Nov. 1-Mar. 1.
Pheasant, English or ringneck	Dec. 1-Jan. 1.
Dove (see exception), teal, wood (summer) duck	Aug. 1-Apr. 15.
Exception: Dove in Shelby County ... Mar. 1-July 15	
Robin, marsh blackbird, plover, curlew, tatler, willet, godwit, sandpiper, snipe, woodcock, avocet, coot, mud hen, rail, duck (except teal and wood duck), goose, brant, swan	Oct. 1-Apr. 15.
Texas (1907):	
Deer (female deer and spotted fawn protected all the year)	Nov. 1-Jan. 1.
Antelope, sheep, 5 years	July 1, 1912.
Quail or partridge, dove	Nov. 1-Feb. 1.
Prairie chicken or pinnated grouse, pheasants (Mongolian, English), 5 years	July 1, 1912.
Wild turkey	Dec. 1-Apr. 1.[d]
Utah (1909):	
Deer (see exception)	Oct. 15-Nov. 15.
Exception: Nonresident not permitted to kill deer.	
Elk, antelope, sheep	Mar. 11, 1913.
Quail, partridge, grouse, prairie chicken, pheasants (Chinese, English, Mongolian) (see exceptions)	Mar. 11, 1913.
Exceptions: Quail in Garfield, Kane, and Washington counties ... Aug. 1-Feb. 1	
Quail in Carbon, Davis, Salt Lake, Sevier, Utah, and Weber counties ... Oct. 1-Nov. 1	
Sage hens in Beaver, Box Elder, Carbon, Emery, Garfield, Grand, Iron, Kane, Millard, Morgan, Piute, Rich, San Juan, Sanpete, Sevier, Summit, Uinta, Wasatch, Washington, Wayne, and Weber counties	Aug. 1-Dec. 1.
Sage hens in Cache, Davis, Juab, Salt Lake, Tooele, and Utah counties	Mar. 11, 1913.
Dove	Aug. 1-Dec. 1.
Snipe, shore birds, duck, goose, brant, swan	Oct. 1-Jan. 1.
Vermont [e] (1894-1908):	
Deer (except spotted or red fawn)	Oct. 25-Oct. 31.[f]
Moose, caribou	No open season.
Hare, rabbit	Sept. 15-May 1.
Gray squirrel	Sept. 15-Dec. 1.

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[a] The game law passed at the recent session of the legislature was declared unconstitutional by the supreme court of Tennessee on July 27, 1909.

[b] *Special squirrel seasons:* Benton, Decatur, Wilson, June 1-Jan. 1; Carroll, June 15-Mar 1; Carter, July 15-Mar. 1; Crockett, Weakley, July 1-Feb. 1; Dyer, June 1-July 1 and Oct. 1-Jan. 1; Fayette, July 15-Jan. 1; Gibson, Sevier, June 1-Feb. 1; Hardeman, July 15-Feb. 15; Haywood, May 1-Jan. 1; Henderson, July 15-Jan. 15; McNairy, Madison, July 1-Mar. 1; Robertson, July 1-Jan. 1; Shelby, June 15-Feb. 1; Stewart, Aug. 1-Feb. 1; Warren, Oct. 1-Mar. 1. Bedford, Blount, Cannon, Clay, Coffee, Cumberland, Dickson, Fentress, Giles, Greene, Hickman, Humphreys, Jackson, Knox, Lawrence, Lincoln, London, Marshall, Maury, Meigs, Moore, Overton, Perry, Pickett, Putnam, Rhea, Sequatchie, Sullivan, Van Buren, Washington, Wayne, White, Williamson, unprotected.

In Chester, Hardeman, Hardin, and McNairy counties anyone may kill squirrels on his own property at any time for his own use.

[c] *Special wild turkey seasons:* Dyer, (gobblers) Nov. 1-May 1, (hens) Nov. 1-Feb. 1; Clay, Fentress, Overton, Pickett, Aug 1-May 1.

[d] But see opinion of assistant attorney-general of Texas dated Sept. 17, 1907, holding that season opens Nov. 1.

[e] The governor is authorized to suspend open seasons in time of drought and fix another open season for deer in such event.

[f] Deer kept in private game preserves may be killed by the owners at any time.

Open seasons for game—Continued.

Vermont (1894-1908)—Continued.	*Open seasons.*
Quail	Sept. 15, 1911.
Ruffed grouse (partridge), woodcock	Sept. 15-Nov. 15.
Pheasant, English partridge	Oct. 1, 1913.
Dove, rail, swan	No open season.
Plover (other than upland), English snipe	Sept. 15-Dec. 1.
Upland plover	Aug. 1, 1915.
Duck, goose	Sept. 1-Jan. 1.
Virginia [a] (1903-1908):	
Deer	Sept. 1-Dec. 1.
Rabbit	Nov. 1-Feb. 1.[b]
Squirrel:	
Alexandria County (gray)	Sept. 1, 1910
Isle of Wight and Southampton counties (gray or fox)	Sept. 1-Jan. 15
Opossum:	
Halifax County	Oct. 15-Feb. 1
Quail or partridge, pheasant or grouse, wild turkey, woodcock (see exceptions)	Nov. 1-Feb. 1.
Exceptions: West of the Blue Ridge	Nov. 1-Jan. 1
Robin	Feb. 15-Apr. 1.
Surf bird, plover, curlew, tatler, willet, sandpiper, snipe (except Wilson and robin snipe), mud hen, gallinule, rail (except sora)	July 20-Jan. 1.
Summer or wood duck	Aug. 1-Jan. 1.
Winter waterfowl	Oct. 15-May 1.[c]
Washington [d] (1903-1909):	
Deer, (except spotted fawns), caribou, sheep, goat	Oct. 1-Dec. 1.
Elk	Oct. 1, 1915.
Moose, antelope (males only)	Sept. 15-Nov. 1.
Spotted fawns, female moose, and antelope	No open season.
Quail, ruffed grouse, grouse, prairie chicken, sage hen, pheasant, and other imported upland game birds (see exceptions)	Oct. 1-Jan. 1.
Exceptions: Quail in Clallam, Clarke, Kitsap, Skagit, and Whatcom counties, and counties east of Cascades	Oct. 1, 1912
Partridge, pheasant (Chinese ringneck, English, and golden), in same counties and also Snohomish County	Oct. 1, 1912
Grouse in Douglas, Ferry, Okanogan, and Stevens counties	Aug. 15-Jan. 1
Grouse in other counties east of Cascades	Sept. 1-Oct. 16
Prairie chicken in Adams, Chelan, Columbia, Douglas, Ferry, Garfield, Grant, Lincoln, Okanogan, Stevens, and Wallawalla counties	Sept. 1-Oct. 16
Prairie chicken in other counties east of Cascades	Sept. 1, 1912
Hungarian partridge	Oct. 1, 1913.
Plover, curlew, snipe, rail, other shore birds, duck, goose, brant, swan (see exception).	Oct. 1-Feb. 1.[e]
Exception: In Adams, Douglas, Ferry, Grant, Lincoln, Okanogan, Spokane, Stevens, and Whitman counties	Sept. 15-Jan. 1
West Virginia (1909):	
Deer (with horns more than 4 inches long—no open season for any other deer)	Oct. 15-Dec. 1.
Rabbit (in Brooke, Hancock, Harrison, Marion, Marshall, and Ohio counties only)	Nov. 2-Dec. 20.
Squirrel (gray, black, red, fox)	Sept. 1-Dec. 1.
Quail (Virginia partridge)	Nov. 1-Dec. 1.
Ruffed grouse (pheasant), wild turkey	Oct. 15-Dec. 1.
Pheasants (English, Chinese, Reeves, Lady Amherst), capercailzie, or any other introduced foreign game bird, dove, wood duck	No open season.
Plover, sandpiper, woodcock, reed bird, rail (ortolan)	July 15-Dec. 20.
Snipe	Oct. 15-Mar. 1.
Duck (except wood-duck), goose, brant	Sept. 1-Apr. 20.

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[a] Boards of supervisors may shorten the open seasons in their counties and make other restrictions not repugnant to law "and may include in such protection other game not specifically mentioned in this section." Code 1904, sec. 2070a as amended in 1906.

[b] Residents of the State may kill rabbits on their own lands at any time.

[c] Wildfowl can not be hunted on Wednesdays and Saturdays on Back Bay, Princess Anne County.

[d] On Mercer Island and shores of Lake Washington game animals and birds are protected all the year (Laws 1909, ch. 54).

[e] Shore birds, geese, and brant may also be shot Mar. 1-June 1 in Chehalis, Clallam, Jefferson, Pacific, and San Juan counties, along the coast and 5 miles inland.

Open seasons for game—Continued.

		Open seasons.
Wisconsin (1898–1909):		
Deer (see exceptions)		Nov. 11–Dec. 1.
Exceptions: Door and Shawano counties, 5 years	Nov. 11, 1912	
Adams, Brown, Buffalo, Calumet, Columbia, Crawford, Dane, Dodge, Fond du Lac, Grant, Green, Green Lake, Iowa, Jefferson, Juneau, Kenosha, Kewaunee, La Crosse, Lafayette, Manitowoc, Marquette, Milwaukee, Monroe, Outagamie, Ozaukee, Pepin, Portage, Racine, Richland, Rock, Sauk, Sheboygan, Vernon, Walworth, Washington, Waukesha, Waupaca, Waushara, and Winnebago counties	No open season	
Moose		No open season.
Rabbit, squirrel (gray, black, fox—see exceptions)		Oct. 10–Feb. 1.
Exceptions: Chippewa, Eau Claire, Pierce, Portage, Rusk, St. Croix, Waupaca, and Waushara counties	Sept. 10–Feb. 1	
Crawford, Grant, Iowa, Kenosha, Lafayette, Richland, Sauk, and Vernon counties (rabbit only)	Unprotected	
Quail, pheasants (Chinese, English, Mongolian), 8 years		Oct. 1, 1915.
Partridge, plover, snipe, woodcock		Sept. 10–Dec. 1.
Prairie chicken, grouse: in Adams, Ashland, Barron, Bayfield, Brown, Burnett, Buffalo, Chippewa, Clark, Crawford, Dodge, Douglas, Dunn, Eau Claire, Grant, Iowa, Jackson, Juneau, Lafayette, Marinette, Marquette, Monroe, Oconto, Outagamie, Pepin, Pierce, Polk, Portage, Richland, Rusk, Sawyer, St. Croix, Vernon, Washburn, Waupaca, Waushara, and Wood counties	Sept. 10–Oct. 1	
Prairie chicken, grouse: in rest of State	Sept. 1, 1915	
Turtle dove, swan		No open season.
Coot or mud hen, rail or rice hen, duck		Sept. 1–Jan. 1.
Goose, brant		Sept. 10–May 1.
Wyoming (1909):		
Deer		Sept. 25–Dec. 1.
Moose, 3 years		Sept. 25, 1912.
Elk, sheep (except in Carbon, Fremont, and Uinta counties and in Big Horn and Park counties west of Big Horn River, Sept. 25–Dec. 1), 3 years		Sept. 25, 1912.
Antelope, 6 years		Sept. 25, 1915.
Quail, Mongolian pheasant, 3 years		Sept. 25, 1912.
Grouse, other than sage grouse (see exception)		Sept. 25–Dec. 1.
Exception: Albany, Carbon, Laramie, and Sweetwater counties	Aug. 1–Sept. 16.	
Sage grouse (except in Natrona and Sheridan counties, Aug. 1, 1915), curlew		Aug. 1–Oct. 1.
Dove, swan		No open season.
Sandpiper, snipe, or other shore bird (except curlew), duck, goose (except goose in Uinta County, Sept. 1–Jan. 1)		Sept. 1–May 1.
Alberta[a] (1906–1909):		
Deer, moose, caribou		Nov. 1–Dec. 15.
Elk or wapiti		Nov. 1, 1910.
Antelope		Oct. 1–Nov. 1.
Buffalo		No open season.
Sheep, goat		Sept. 1–Oct. 15.
Partridge (except Hungarian partridge, Oct. 1, 1911), grouse, prairie chicken, ptarmigan, pheasant (except English, no open season)		Oct. 1–Nov. 1.
Plover, curlew, sandpiper, snipe, shore bird, coot, rail, crane		Sept. 1–Jan. 1.
Duck,[b] swan		Aug. 23–Jan. 1.

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[a] North of latitude 55° any game animal or bird, except elk and buffalo, may be killed at any time if needed for food.

[b] Except whitewinged scoters, north of township 50, which may be taken at any time.

Open seasons for game—Continued.

British Columbia [a] (1898–1909:)	*Open seasons.*
Deer (except Coast or Columbian, no open season), goat	Sept. 1–Dec. 15.
Bull elk or wapiti, bull moose, bull caribou, hare	Sept. 1–Jan. 1.
Sheep, rams only	Sept. 1–Nov. 15.
Young of deer and females and young of elk, moose, caribou, and sheep	No open season.
Bear	Sept. 1–July 15.
Quail, English partridge, prairie chicken, pheasant, black game, capercailzie, snipe, swan	No open season.[a]
Grouse, ptarmigan, duck north of latitude 55° (in rest of province no open season)	Sept. 15–Apr. 1.
Plover	Sept. 1–Mar. 1.
Manitoba (1909):	
Deer, elk or wapiti, moose, caribou or reindeer, antelope or cabri (males)	Dec. 1–Dec. 15.
Females and young of foregoing species and bison or buffalo	No open season.
Quail, woodcock, plover (except upland plover), sandpiper, snipe	Aug. 1–Jan. 1.
Partridge, prairie chicken, grouse	Oct. 1–Oct. 20.
Dove	No open season.
Pheasant, 11 years	Oct. 1, 1920.
Upland plover	July 1–Jan. 1.
Duck	Sept. 1–Dec. 1.
New Brunswick (1909):	
Deer, moose, caribou (cow and calf moose and cow caribou, no open season)	Sept. 15–Dec. 1.
Partridge	Sept. 15–Dec. 1.
Pheasant	No open season.
Snipe, woodcock, teal, wood duck, dusky or black duck, goose, brant	Sept. 15–Dec. 2.
Shore or other birds on beaches, islands, or lagoons bordering tidal waters of Northumberland Strait, Gulf of St. Lawrence, and Bay of Chaleur	Sept. 15–Jan. 1.
Newfoundland [b] (1902–1908):	
Elk, moose, 10 years	Jan. 1, 1912.
Caribou (except in a special region near Grand Lake, no open season)	Oct. 21–Feb. 1.[c]
Rabbit, hare	Oct. 1–Dec. 15.[d]
Ptarmigan, willow grouse or partridge, plover, curlew, snipe, or "other wild or migratory birds (except wild geese)"	Oct. 1–Dec. 15.
Capercailzie, black game, 10 years	Oct. 12, 1917.
Nova Scotia (1908–1909):	
Deer, caribou, 4 years	Oct. 1, 1912.
Moose (see exceptions)	Sept. 16–Nov. 16.
Exceptions: Cape Breton Island	Oct. 1, 1915.
Calf moose under 1 year	No open season.
Cow moose	Sept. 20, 1912.
Hare, rabbit	Nov. 1–Feb. 1.
Ruffed grouse or birch partridge	Oct. 1–Nov. 1.
Canada grouse (spruce partridge), chukar partridge, pheasant, capercailzie, black game	No open season.
Quail, sharp-tailed grouse, ptarmigan, plover, curlew, yellow-legs, sandpiper, snipe, woodcock, heron, bittern, beach birds, waders, teal, bluewinged duck (see exception), wood duck	Sept. 1–Mar. 1.
Exception: Cumberland County (bluewinged duck)	Sept. 1–May 1.

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[a] The lieutenant-governor is empowered to make further restrictions in these seasons, and to open seasons now closed. Resident Indians (nonresidents not allowed to hunt) and farmers in "unorganized districts" may kill deer for immediate use as food, but Indians can kill does and fawns only Aug. 1–Feb. 1; free miners while engaged in placer mining or prospecting in unorganized districts, and surveying or engineering parties engaged in their duties may kill any game for food. The following special seasons have been made by orders in council: In the Okanagan electoral district prairie chickens, willow grouse, and blue grouse are protected until September 1, 1910; in the Lillooet and Cariboo electoral districts the open season for mountain sheep closes November 14 in each year; in the East Kootenay district moose are protected all the year; south of the Canadian Pacific Railway, from the coast to Columbia River and from Revelstoke to the international boundary, sheep are protected all the year; and in that part of the Lillooet district known as the Yalakom Mountain district (game reserve) all protected animals and birds and also geese are protected absolutely until October 4, 1917.

[b] Poor settlers may kill any birds, except capercailzie and black game, at any time, for immediate consumption by themselves or their families.

[c] Additional open season Aug. 1–Oct. 1.

[d] Snaring or trapping permitted Oct. 1–Mar. 1.

Open seasons for game—Continued.

	Open seasons.
Ontario[a] (1907-1909):	
Deer (young protected all the year)	Nov. 1-Nov. 16.[b]
Elk or wapiti	No open season.
Moose, caribou, or reindeer (see exception)	Oct. 16-Nov. 16.[c]
Exception: Female moose and young moose and caribou	No open season.
Hare[d]	Oct. 1-Jan. 1.
Squirrel (black or gray)	Nov. 1-Dec. 2.
Quail, wild turkey	Nov. 1-Dec. 2.
Prairie fowl, capercailzie, woodcock	Sept. 15-Dec. 16.
Partridge, grouse	Sept. 15, 1910.
Pheasants (English or Chinese), 3 years	Sept. 15, 1910.
Plover, snipe, rail, other shore birds or waders	Sept. 1-Dec. 16.
Dove	No open season.[e]
Duck and other waterfowl (except goose and swan)	Sept. 1-Jan. 1.
Goose, swan	Sept. 15-May 1.
Prince Edward Island (1906-1907):	
Hare, rabbit	Sept. 1-Mar. 1.
Partridge	Oct. 1-Dec. 1.
Plover, curlew	July 15-Jan. 1.
Snipe, woodcock	Sept. 1-Jan. 1.
Yellow-legs, shore and other birds along beaches or tidal marshes, teal, black or blue winged duck	Aug. 20-Jan. 1.
Goose	Sept. 15-May 10.
Brant	Oct. 1-June 10.
Quebec (1899-1908):	
Zone 1.[f] Deer, moose (see exceptions)	Sept. 1-Jan. 1.
Exceptions: In Ottawa and Pontiac counties	Oct. 1-Dec. 1.
Cow moose and young deer and moose	No open season.
Caribou (young protected all the year)	Sept. 1-Feb. 1.
Hare	Dec. 1-Feb. 1.
Bear	Aug. 20-July 1.
Birch or swamp partridge	Sept. 1-Dec. 15.
White partridge or ptarmigan	Nov. 1-Feb. 1.
Woodcock, plover, curlew, tatler, sandpiper, snipe	Sept. 1-Feb. 1.
Widgeon, teal, duck (except sheldrake), gull, loon	Sept. 1-Mar. 1.[g]
Saskatchewan[h] (1905-1907):	
Zone 2. Close seasons same as in Zone 1, except as follows:	
Caribou	Sept. 1-Mar. 1.
Hare	Oct. 15-Mar. 1.
Birch or swamp partridge	Sept. 15-Feb. 1.
White partridge or ptarmigan	Nov. 15-Mar. 1.
Deer, elk or wapiti, moose, caribou (females and young no open season)	Dec. 1-Dec. 15.
Antelope (young all the year)	Oct. 1-Nov. 15.
Buffalo	No open season.
Partridge, prairie chicken, grouse, ptarmigan	Sept. 15-Dec. 1.
English pheasant	No open season.
Plover, curlew, sandpiper, snipe, shore birds, coot, rail, duck, goose, swan	Sept. 1-Jan. 1.
Crane	Aug. 1-Jan. 1.

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[a] Lieutenant-governor in council may alter close seasons in region north and west of French River, Lake Nipissing, and Mattawa River, and in the vicinity of Rondeau Park, and close for a definite period seasons for any game animal or nonmigratory game bird whose numbers have diminished.

[b] Persons who put or breed deer on their own lands, and their licensees, may hunt such deer Oct. 1-Nov. 16.

[c] South of the Canadian Pacific R. R., between Mattawa and the Manitoba boundary, Nov. 1-16.

[d] Cottontail rabbits (wood hares) may be killed during close season when damaging trees or shrubs.

[e] Under act for protection of insectivorous birds, Rev. Stats., 1897, ch. 289, sec. 3.

[f] Zone No. 1 comprises the whole Province, except that part of the counties of Chicoutimi and Saguenay east and north of the river Saguenay. Zone No. 2 comprises the excepted part of said counties.

[g] Inhabitants of Zone 2 and Gaspé County may take these birds for food Aug. 1-June 1.

[h] Lieutenant-governor in council may extend close seasons over current year within limits on petition of 6 game guardians.

Open seasons for game—Continued.

Unorganized Territories [a] (Keewatin, Mackenzie, etc.), (1894–1906):	
Deer, elk or wapiti, moose, caribou, goat, sheep	Dec. 1–Apr. 1.[b]
Buffalo	Jan. 1, 1912.
Musk ox	Oct. 15–Mar. 20.
Partridge, prairie chicken, grouse, pheasant	Sept. 1–Jan. 1.
Duck, goose, swan	Sept. 1–Jan. 15.
Yukon [c] (1902–1906):	
Deer, elk or wapiti, moose, caribou, sheep, goat, musk ox	Sept. 1–Mar. 1.
Bison or buffalo	No open season.
Partridge, prairie chicken, grouse, ptarmigan, pheasant	Sept. 1–Mar. 15.
Sandpiper, snipe, crane, duck, goose, swan	Aug. 10–June 1.

SHIPMENT OF GAME.

Shipment is the most important feature of the traffic in game. It has a marked effect upon the perpetuation of game, and when permitted without limitation is a great factor in its rapid destruction. A realization of this fact has induced many of the States to prohibit export of all or certain kinds of game, and in a few instances all transportation even within the State. The subject may be conveniently considered under the following subheads: "Federal laws," "Marking packages," and "State laws prohibiting export."

FEDERAL LAWS.

Federal laws affecting the shipment of game comprise the statutes regulating interstate commerce in game and the importation of birds from foreign countries and those providing for the protection of birds and game on territory under the immediate jurisdiction of the United States.

They comprise: (1) The Lacey Act, regulating the importation of game and its shipment from one State to another; (2) the tariff act, imposing duties on game, skins, and feathers imported from foreign countries; (3) the act regulating the introduction of eggs of game birds; (4) the game law of Alaska; and (5) provisions for protecting birds in the National parks,[d] National Forests, and other Government reservations. These laws are more fully discussed in Bulletin No. 16 of the Biological Survey, entitled "Digest of Game Laws for 1901" (pp. 69–79). The full text of several may be found in various circulars published by the Biological Survey: Circular No. 29 (1900) contains the Lacey Act, and Circulars Nos. 66 and 68 the new Alaskan game law of 1908, with the regulations now in force.

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[a] Indians, inhabitants, travelers, explorers, and surveyors in need of food exempt. Governor in council may alter seasons.

[b] Also July 15–Oct. 1.

[c] Indians, explorers, surveyors, prospectors, miners, and travelers in need of food are exempt. Commissioner in council may alter seasons.

[d] The law governing the Yellowstone Park prohibits any person, or any stage, express, or railway company from receiving for transportation animals, birds, or fish taken in the park, under a penalty not exceeding $300. (28 Stat. L., ch. 72, sec. 4.)

STATE LAWS PROHIBITING EXPORT.

Since the constitutionality of the Connecticut statute prohibiting export of certain game was established by the supreme court in 1896, nonexport laws have been generally adopted, and at the present time every State prohibits the export of certain kinds of game. In some States sportsmen are allowed to carry a limited amount of game out of the State under special restrictions, and exceptions to the laws prohibiting export are also made in the case of birds and animals intended for propagation.

Restrictions on shipment from the State have now become so stringent that all the States and Territories west of the Mississippi River, except two, North and South Dakota, prohibit export of all game protected by local laws, and these permit the export of only plover, woodcock, and cranes. East of the Mississippi, laws prohibiting the export of all game, or, in some cases, all but one or two unimportant species, are in force in all the States except a small group along the coast from Massachusetts to Maryland and four Southern States—North Carolina, Georgia, Florida, and Kentucky.

Special attention is called to the following table, which contains a list of the game prohibited from export by each State and Territory:

Export of Game Prohibited.

Alabama: All game protected by the State.

Exceptions: Nonresident licensee may take with him or have carried to him, openly, game lawfully killed by him. State game and fish commissioner may issue permit to any person to capture, kill, or export game birds at any time, dead or alive, for scientific or propagating purposes.

Alaska: Deer, moose, caribou, sheep, goat, bear, or hides of these animals; wild birds, except eagles, or any parts thereof.

Exceptions: Specimens may be exported under restrictions imposed by the Secretary of Agriculture, and trophies of big game under licenses issued by the Governor.[a]

Arizona: All game protected by the State, and duck, goose, and brant.

Arkansas: Deer (unless raised in captivity), wild turkey, wild fowl, game of any description except rabbits, which must be shipped open to view. (Squirrels can not be shipped out of Craighead, Dallas, Lafayette, and White counties.) Local exceptions in Clay and Mississippi counties.

California: All game protected by the State.

Colorado: All game protected by the State.

Exception: Game may be exported under permit from game commissioner if permit be attached and package plainly marked so as to show nature of contents. The following fees are charged for export permits: Elk, $10; deer, $5; sheep, $5; bird, 25 cents—in each case the edible portion alone.

Connecticut: Quail, ruffed grouse, woodcock.

Delaware: Rabbit, quail, partridge, woodcock (nonresidents also prohibited from shipping English snipe).

Florida: Deer, deer hides, quail or partridge, wild turkey from county.

Georgia: Quail or partridge.

Idaho: All game protected by the State.

Exception: Any hunter may export, under hunting license, big game lawfully taken, under a 50-cent permit obtained from a justice of the peace, probate judge, game warden, or deputy game warden on a sworn statement to issuing officer that game was not procured contrary to law. Mounted heads and stuffed birds legally secured may be exported.

Illinois: Squirrel, quail, ruffed grouse, pinnated grouse, prairie chicken, pheasant, wild turkey, shore birds, duck, goose, brant, taken in the State.

Exceptions: Game may be exported under license from the State. Nonresident may take from State 50 birds killed by himself, if carried openly for inspection.

Indiana: Deer, quail, grouse, prairie chicken, pheasant, wild turkey, woodcock, duck, goose, brant, and other water fowl.

Exception: Nonresident may take from State 15 birds killed by himself, if carried openly for inspection, together with his license, or 45 if he has hunted for 3 or more days consecutively.

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[a] See p. 46 and also Circulars Nos. 66 and 68, Biological Survey, U. S. Department of Agriculture, 1908.

Export of Game Prohibited—Continued.

Iowa: All game protected by the State.

Exception: Nonresident may take from State not more than 25 game birds or animals, if carried openly for inspection, and if hunting license be shown on request.

Kansas: All game protected by the State.

Kentucky: Quail, partridge, grouse, pheasant, wild turkey, killed in the State.

Louisiana: All game protected by the State.

Exception: A nonresident licensee may carry with him out of the State, twice a season, a limited amount of game, under his license, or as baggage, if exposed to view.

Maine: Deer, moose, quail, ruffed grouse, pheasant, capercailzie, black game, plover, woodcock, snipe, sandpiper, wood duck, dusky or black duck, teal, gadwall or gray duck, mallard, widgeon or baldpate, shoveler, pintail or sprigtail, redhead, scaup or greater bluebill, lesser scaup or lesser bluebill, golden-eye or whistler, bufflehead, ruddy duck or broadbill.

Exceptions: A resident of the State may export 1 deer in a season if open to view, tagged to show name and address of owner and accompanied by him, and under shipping license 1 moose, 6 partridges, 10 woodcock, and 10 ducks lawfully killed by himself. A nonresident may export under hunting license 1 moose and 2 deer lawfully killed by himself and may take home 10 partridges, 10 ducks, and 10 woodcock. Any person may export a pair of game birds under a special 50-cent license.

Maryland: *County provisions, as follows:*

Allegany—All game, viz: Deer, squirrel, rabbit, partridge or quail, pheasant, turkey, woodcock, duck, goose, brant, swan, from county.

Anne Arundel—All game, viz: Squirrel, rabbit, quail, partridge, pheasant, woodcock, snipe, plover, duck, goose, brant, swan from county.

Baltimore—Partridge, pheasant, woodcock from county.

Calvert—Rabbit, partridge, woodcock from county (for sale, barter, or trade).

Caroline—Rabbit, quail, partridge, woodcock from county.

Dorchester—Squirrel, rabbit, quail, partridge, woodcock, dove (for sale).

Exception: Twelve quail or partridges, 6 squirrels, rabbits, woodcock, and doves may be taken out of the county as personal baggage, if carried openly and not intended for sale.

Frederick—Squirrel, partridge, pheasant, woodcock from county (for sale).

Garrett—Partridge (quail), pheasant, wild turkey, woodcock from county.

Exception: Nonresident may take out game killed under his hunting license.

Kent—Squirrel, rabbit, and all birds from county (for sale, except under license).

Montgomery—Partridge, pheasant, wild turkey from county (for sale).

Queen Anne—Rabbit, partridge, woodcock from county (for sale).

Somerset—All game, viz: Squirrel, rabbit, quail or partridge, pheasant, dove, woodcock, duck, goose from county.

Washington—Deer, squirrel, rabbit, partridge, pheasant, woodcock, wild turkey from county (for sale)

Wicomico—Quail or partridge from Wicomico and Worcester counties considered as one territory.

Worcester—Rabbit, quail, woodcock from county.

Massachusetts: Quail, ruffed grouse, woodcock taken in State; other game illegally taken in State.

Exception: Nonresident may take 6 birds out of the State under his hunting license.

Michigan: All game protected by the State.

Exceptions: (1) Game consigned to a point within the State may be transported outside the State if necessary to reach destination.

(2) Nonresident licensee may take out 1 deer under permit from State warden.

(3) Landowners and members of clubs owning game preserves may ship during open season under a $10 permit from State warden 50 ducks or other migratory birds killed by them on their own premises.

Minnesota: All game protected by the State.

Exception: Nonresident licensee may ship home in open season under his license coupons 1 deer and 25 birds lawfully taken by himself. Domesticated big game may be exported under permit.

Mississippi: All game protected by the State.

Missouri: All game protected by the State.

Exceptions: Game may be exported under resident or nonresident license if carried openly as baggage or express or in owner's possession and accompanied by him. Export for scientific or propagating purposes allowed under permit. Deer or elk raised in captivity may be shipped at any time.

Montana: All game protected by the State.

Exception: Game lawfully killed may be exported during the open season if accompanied by the owner, and when shipped by resident of State, by permit from state game and fish warden, or when shipped by nonresident of State, by hunting license; total shipment under one license not to exceed number allowed to be killed in one season; all packages to be plainly labeled to show nature of contents.

Nebraska: All game protected by the State.

Exception: Nonresident may ship 50 birds out of State under hunting license, but must give common carrier invoice of number and kind of birds, must have details of shipment marked on license, and must accompany the shipment.

Nevada: All game protected by the State.

Export of Game Prohibited—Continued.

New Hampshire:[a] Deer (except heads for mounting), elk, moose, caribou, quail, partridge, ruffed grouse pheasant, woodcock, Wilson snipe, dove, plover, yellowlegs, sandpiper, rail, duck (except sheldrake), and all "beach" birds.

Exception: Deer may be exported by resident if accompanied to office of carrier by owner; shipped open to view, properly tagged, and labeled with name of actual owner. Nonresident may export, under his hunting license, 2 deer and 12 birds, carried open to view, on notice of number and kind to the commissioner who issued the license.

New Jersey: Squirrel, hare, rabbit, quail or partridge, ruffed grouse or pheasant, pinnated grouse, English pheasant, ringneck pheasant, woodcock.

Exception: English or ringneck pheasants killed on preserves established prior to April 15, 1903, may be exported from the State. Nonresident licensee may export 10 rabbits and 15 birds a day if carried openly.

New Mexico: Export for market of all game protected by the State.

Exception: The territorial warden is authorized to issue transportation permits at $1 each ($2 in case of deer), and also to permit export of game or birds for scientific or propagating purposes.

New York: Game or birds taken in the State.

Exception: Nonresident may export one deer under his hunting license. Head, feet, and skins of deer legally captured may be exported if carried separately. Deer propagated in inclosed parks may be exported under permit of forest, fish, and game commissioner.

North Carolina:[b] Quail, partridge, pheasant, grouse, wild turkey, snipe, shore or beach bird, woodcock taken in State.

Exception: Nonresident may take out of State under his hunting license 50 quail (partridges), 12 grouse, 2 turkeys, and 50 beach birds or snipe in a season.

North Dakota: All game protected by the State, except golden and upland plover, woodcock, and crane

Exception: Nonresident licensee may carry with him from State 2 deer, and grouse, prairie chickens, doves, cranes, and swans not exceeding 20 in all, and plover, snipe, ducks, geese, and brant not exceeding 50 in all, open to view, labeled with his name and address and number of his license. Domesticated game may be exported under written permission of board of control.

Ohio: Squirrel, quail, ruffed grouse or pheasant, introduced pheasant, dove, woodcock, plover, snipe, shore birds, rail, coot (mud hen), duck, goose, swan taken in the State.

Exception: Nonresident may take with him from State under his hunting license 50 pieces of game.

Oklahoma: All game protected by the State.

Exception: Nonresident licensee may carry to his home 2 days' bag limit of game birds.

Oregon: All game protected by the State.

Exception: Any citizen of Washington may take one day's bag with him out of the State. Ringneck pheasants or other birds raised in captivity for breeding purposes and pinioned may be shipped with consent of state game warden. Game for propagation or scientific purposes may be exported under permit.

Pennsylvania: All protected game taken in the State.

Exception: Nonresident licensee may take with him from the State one day's bag labeled with his name and address and number of his license. Live English, Mongolian, and Chinese pheasants raised in captivity may be exported.

Rhode Island: Quail, ruffed grouse, and woodcock.

Exception: Nonresident may take with him from the State under his hunting license, open to view 10 wild fowl or birds the export of which is otherwise prohibited by law.

South Carolina: All game birds or animals taken in the State.

Exception: Licensee may carry openly 2 deer, 50 partridges, 12 ruffed grouse, 4 wild turkeys, 50 beach birds, 50 ducks and geese in a season.

South Dakota: All game protected by the State, except woodcock and golden and upland plover.

Exception: Two deer, 1 elk, 1 buffalo, 1 mountain sheep. A certificate—good for 5 days—that such game was lawfully killed must be obtained from a justice of the peace and given to the carrier. Any resident or nonresident may carry out of the State any game bird legally in possession. Game or game birds raised in captivity may be exported under written permission of state game warden.

Tennessee: All game protected by the State.

Exception: Nonresident may take with him from the State 50 ducks or 30 pieces of other game, but must present to some officer or employee of common carrier his hunting license and sworn statement that his game is not for sale and will not be sold.

Texas: All wild animals, wild birds, and wild fowl found in the State.

Exception: Nonresident licensee may carry out one day's bag.

Utah: All game protected by the State.

Exception: Nonresident licensee may take one day's bag out of State under permit.

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[a] Blue Mountain Forest Association permitted to ship deer, elk, and moose killed in its preserve.

[b] The following county laws are also in force: Brunswick, Dare, New Hanover—Wild fowl, March 10-November 10 from county. Catawba, Harnett, Iredell, Jackson, Rutherford, Surry, Swain—Quail from county.

Export of Game Prohibited—Continued.

Vermont: Deer, gray squirrel, quail, ruffed grouse or partridge, plover, English snipe, woodcock, duck, goose.

Exception: Nonresident licensee may export one deer and one day's bag of game birds under license. Resident may export, open to view, the season limit of game or game birds under his license by having the license marked with shipping point, destination, and number of each kind of game.

Virginia: All game protected by the State.

Exceptions: During open season nonresident may, under his hunting license, take with him out of the State, or as baggage on the same conveyance, 1 deer, 50 quail or partridges, 10 pheasants or grouse, 3 wild turkeys, 30 waterfowl, and 25 of each, or 100 in all, of plover, snipe, sandpipers, willets, tatlers, and curlew, if killed or captured by himself, and shipped open to view and plainly labeled with his name and address. Any citizen of State may ship from the State, as a gift and not for sale (which fact must be stated on shipping tag), 1 deer, 18 quail or partridges, 6 pheasants, 3 wild turkeys, and 12 waterfowl, if open to view and plainly labeled with names and addresses of donor and donee, and number of each kind of bird so shipped.

Washington: All game protected by the State.

Exception: Nonresident may export one season's limit of big game and one day's bag limit of birds under his hunting license, if accompanied by affidavit that the game was killed by him and is not for sale. Export of game animals and birds raised in captivity permitted.

West Virginia: All game protected by the State.

Wisconsin: All game protected by the State, except rabbit, squirrel, and coot (mud hen).

Exception: During open season nonresident may take out of State under his hunting license, in personal possession or as baggage or express, accompanying same to state line, 1 deer and not more than 30 game animals and birds of all kinds, provided packages are plainly marked so as to show the names and addresses of shipper and consignee and number of each kind of game, and, in case of deer, have proper coupons attached. Park boards allowed to ship, under permit of state game warden, live animals and game birds for park purposes. Shipment allowed of domesticated deer, moose, elk, and caribou, properly tagged, under permit of state game warden.

Wyoming: All game protected by the State.

Exceptions: Smithsonian Institution or other well-known scientific institutions may export any game animals or birds under permit of state game warden.

Export of 1 hide, 1 scalp, 1 head, 1 pair of tusks, 1 skin, 1 mounted head, 1 mounted specimen, of any big game except moose permitted upon affidavit that they were taken from animals lawfully killed, the payment of 25 cents to the justice of the peace of precinct where affiant lives, and attachment of the tag issued by him; a nonresident (or resident, when necessary to cross territory of another State to reach his home) may export under his hunting license 20 dead game birds and the carcass, head, antlers, scalp, skin, and teeth of any animal lawfully killed; exchange of game animals and birds for others for liberation in Wyoming allowed under permit of the state game warden; big game, except moose, captured and held for propagation may be exported 5 years from date of capture.

Alberta: All game protected by the province.

Exceptions: Minister of agriculture on receipt of a $5 fee may grant a permit to export for propagation or scientific purposes one pair of each species of big game and game birds. The lieutenant-governor in council may grant permits for a greater number. The Minister of agriculture may also issue permits for export of game for other purposes at the rate of $5 for each head of big game and $1 per dozen for game birds. The holder of a general nonresident license may take with him out of the province as trophies heads, skins, and hoofs of big game legally killed by him. Any person may export mounted or branded heads at a fee of $1 for each head.

British Columbia: All game protected by the province except bears.

Exceptions: Heads, horns, and skins of big game lawfully killed by the shipper may be shipped under his hunting license. Any animal or bird, dead or alive, may be exported for scientific, zoological, or government purposes under permit by Provincial Secretary. Live game birds or animals held in captivity under written permission of provincial game warden may be exported.

Manitoba: All game protected by the province.

Exception: Minister of agriculture and immigration may direct chief game guardian to export not more than 12 animals or birds for propagation and may issue permit to export heads and skins of big game animals, and any game birds, except grouse, prairie chicken, and partridge, but not more than 100 geese and swans or 50 ducks, and these only under nonresident license. (No export of ducks permitted before October 1.) The following export fees are charged: Deer or deer head, $2; head of elk, moose, or caribou, $5; any hide, 10 cents. No export fee required of nonresident licensee.

New Brunswick:[a] All game protected by the province.

Exception: Surveyor-general may issue special license to export game alive or dead.

Newfoundland: Caribou (antlers, heads, or skins), or partridge, willow or other grouse for sale.

Exceptions: Minister of marine and fisheries may issue special licenses to export caribou for breeding or scientific purposes. Nonresident may export 3 stag caribou under hunting license and export permit (fee, 50 cents); resident may export antlers, head, or skin of caribou under export permit; but not, in either case, for sale.

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[a] Except in the case of partridge the prohibition applies only to common carriers.

Export of Game Prohibited—Continued.

Nova Scotia: All game protected by the province.

Exceptions: Holder of general license may ship out of province one moose lawfully shot by himself. Mounted heads and dressed skins and live mammals or birds for propagation may be exported under permit from Provincial Secretary.

Ontario: All wild game animals and birds.

Exceptions: Two deer, 1 bull moose, 1 bull caribou, and 100 ducks may be exported under nonresident hunting license if shipping coupon and, if required, affidavit of lawful killing be attached and contents of packages be open to view. Lawfully imported game and deer, moose, elk, or caribou held by private ownership may be exported.

Prince Edward Island: All game except geese and brant.

Exception: Nonresident licensee may carry out of province 12 birds killed by himself.

Quebec: Native deer, moose, caribou, or parts thereof, except under permit from Minister of colonization, mines, and fisheries (fee not to exceed $5) or under tags attached to nonresident licenses, and not later than 15 days after close of season.

Saskatchewan: All game protected by the province.

Exceptions: Commissioner of agriculture may grant permits to export for propagation for public parks and zoological gardens or scientific purposes 1 pair of each species of big game and game birds upon payment of $5, or a specified number on application of another province or State. The holder of a general nonresident license may take with him out of the province as trophies heads, skins, and hoofs of big game which he has legally killed.

Yukon: Protected game can be exported by a nonresident only under a hunting license and a shipping permit issued by the Commissioner of the Territory or a game guardian.

Canada also has a general law prohibiting export of deer (except those raised on private preserves), wild turkeys, quail, partridges, prairie fowl, and woodcock, and permitting each nonresident to export two deer in a year at certain ports within fifteen days after the close of the open season, under permit of the collector of customs of the port from which export is made. The ports of export are: Halifax and Yarmouth, Nova Scotia; Macadam Junction, New Brunswick; Quebec and Montreal, Quebec; Ottawa, Kingston, Niagara Falls, Fort Erie, Windsor, Sault Ste. Marie, and Port Arthur, Ontario; and such others as the Minister of Customs may designate.

Those who visit Canada to hunt, camp, etc., must deposit with the customs officer at the port of entry an amount equal to the duty (30 per cent of appraised value) on their guns, canoes, tents, cooking utensils, and kodaks. If these articles are taken out within six months at the same port, the deposit will be returned. But members of shooting or fishing clubs that own preserves in Canada and have filed a guaranty with the Canadian commissioner of customs may present club membership certificates in lieu of making the deposit. They must, however, pay duty on all ammunition and provisions.

SALE.

Legislation restricting the sale of game is passing through a transition stage. Some States prohibit the sale of game throughout the year, others only in close season, and between these extremes may be found all gradations and exceptions, such as restrictions prohibiting sale of game outside the State or for export, and exemptions allowing sale for a few days in the close season. The difficulty of tabulating such regulations is increased by the fact that in addition to the special sale laws, close seasons and provisions regarding possession must be taken into consideration. In consulting the following summary, therefore, it will be necessary to bear in mind three different classes of restrictions: "Sale in close season," "Sale in open season," and "Sale prohibited all the year."

SALE IN CLOSE SEASON.

In general, the sale of game is prohibited during the close season, but a brief additional open period is sometimes provided in order to permit dealers to close out stock on hand at the end of the hunting season. In Colorado, Illinois, Nebraska, Tennessee, and British Columbia the sale season includes the open season and the following five days for all or certain kinds of game. An extension of ten days for sale is added to the open season in New Brunswick; fifteen days in Alaska, New Jersey, and Quebec; thirty days in Pennsylvania; sixty days in Yukon; three months (for goose and brant) in New Brunswick; and until the following 1st of January in Ontario.

SALE IN OPEN SEASON.

In order to counteract a tendency on the part of market hunters to anticipate the opening of the season, the sale of certain game is sometimes prohibited at the beginning of the open season, as during the first two days in Illinois, the first three in Nova Scotia, and the first month in British Columbia.

SALE PROHIBITED ALL THE YEAR.

Forty-three States and Territories[a] and most of the provinces of Canada now prohibit sale of all or certain kinds of game at all seasons. In Alabama, Arizona, Arkansas, Colorado, Idaho, Iowa, Kansas, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Oklahoma, Texas, Washington, and West Virginia the sale, and in Nevada the resale, of all game protected by the State law is prohibited; in Ohio, of all game except rabbits; in Wisconsin, of all game except rabbits and squirrels; in California, Utah, Washington, and Manitoba, of all big game and upland game. In a few instances prohibitions against the sale of certain game are so general as to afford protection over a considerable area in adjoining States. Thus, ruffed grouse can not be sold in any State or Province along the Canadian border except New York, Pennsylvania, and Quebec, Practically every State in which prairie chickens occur now prohibits their sale or export.

The following table shows the kinds of game, sale of which is prohibited throughout the year. The sale of all other game is so generally prohibited during the close season as to render a detailed enumeration unnecessary, but when an extension of a few days is added to the open season or a special season is provided for either possession or sale, attention is called to this exemption under the heading "Permitted."

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[a] Omitting Alaska, which prohibits sale only of heads, skins, and trophies; District of Columbia, which prohibits sale only in close season; North Carolina and Tennessee, which prohibit sale in only a few counties; Georgia, Louisiana, and New Jersey.

Sale of Game Prohibited throughout the Year.

Alabama: All game protected by the State.

Alaska: Heads, hides, and skins of all protected game.

Permitted: Carcasses of all game may be sold during the open season and 15 days thereafter.

Arizona: All game protected by the Territory and snipe, rail, duck, goose, and brant.

Arkansas: All "game, wild fowl, or birds whatsoever," except deer raised in captivity, bears, rabbits, opossums, raccoons, and squirrels.[a]

California: Deer meat and hides of female deer, or those from which evidence of sex has been removed, quail, partridge, grouse, pheasant, sage hen, dove, ibis, snipe, plover, rail, or shore birds.

Colorado: All game taken in the State.

Permitted: Domestic game may be sold by hotels, restaurants, etc., during the open season and five days thereafter, or during the limits of a storage permit. Imported game (under license) and game taken from licensed private parks and lakes may be sold at any time if accompanied by an invoice.

Connecticut: Quail, ruffed grouse, woodcock, until October 1, 1911.

Delaware: Quail, partridge, pheasant; buying for sale prohibited.

Florida: Deer, deer hides, quail or partridge, wild turkey.

Idaho: All game protected by the State.

Illinois: Deer, squirrel (gray, red, fox, black), quail, ruffed grouse, prairie chicken, imported game birds, wild turkey, shore birds, coot, rail, duck, goose, and brant.

Permitted: Deer bred in captivity may be sold October 1 to February 1; cock pheasants may be sold by breeders (under permit of state game commissioner) in November and December; doves, woodcock, snipe, plover, coot, and rail may be sold from the third day of the open season to the fifth day of the close season; and legally killed game imported from other States from October 1 to February 1.

Indiana: Quail.

Iowa: All game protected by the State.

Kansas: All game protected by the State.

Kentucky: Quail, partridge, grouse, pheasant, wild turkey, killed in the State.

Louisiana:

Permitted: Game birds may be sold during open season, but not later than March 1.

Maine: Deer, moose, or game birds for export. Ruffed grouse, woodcock, ducks, for any purpose.

Permitted: Deer may be sold by local dealers under license.

Maryland:

Anne Arundel—All game except squirrel, rabbit, and raccoon.
Baltimore—Partridge, pheasant, woodcock for export.
Calvert—Rabbit, quail, woodcock for export for sale.
Frederick—Squirrel, partridge, pheasant, woodcock, taken in county.
Montgomery—Partridge, pheasant, wild turkey, for export.
Somerset—Rabbit, quail or partridge, woodcock, dead or alive, for any other purpose than as food within the county or for propagation; or any game for export.
Washington—Deer, squirrel, rabbit, partridge, pheasant, wild turkey, woodcock
Wicomico—Quail or partridge for export (from Wicomico and Worcester counties considered as one territory).
Worcester—Rabbit, quail, woodcock (except to consumer).

Permitted: Baltimore City—Ruffed grouse may be sold October 1–December 25.

Massachusetts: Deer (to November 1, 1910), gray squirrel, and quail taken in the State, ruffed grouse, heath hen, prairie chicken, sharp-tailed grouse, pheasant, piping plover, killdeer plover, woodcock, and wood duck.

Permitted: Dealers or persons in the cold-storage business may sell imported quail lawfully obtained during November and December, and may sell at any time hares or rabbits lawfully secured. Live quail for propagation may be sold under permit. Deer and pheasants raised in captivity may be sold at any time.

Michigan: All game protected by the State.

Minnesota: All game protected by the State.

Mississippi; All game protected by the State.

Missouri: All game protected by the State.

Montana; All game protected by the State.

Nebraska: All game protected by the State.

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[a] Squirrels killed in Ouachita and Union counties can not be sold, and no squirrels can be sold in Craighead, Dallas, and Lafayette counties.

Sale of Game Prohibited throughout the Year—Continued.

Nevada: Resale of all game.

New Hampshire: Deer (except 2), gray squirrel (to October 1, 1913), ruffed grouse or partridge, woodcock.

New Jersey:

Permitted: All small game may be sold during open season and, if native game, 15 days thereafter.

New Mexico: All protected game except plover, curlew, and snipe.

New York: Quail, grouse, and woodcock taken in the State.

Permitted: Deer may be sold from September 16 to November 6. Moose, elk, caribou, and antelope imported or killed in a private park by the owner during the open season for deer may be sold at any time; and imported quail, grouse, and woodcock under bond during the open season and until January 3. Pheasants bred or liberated in Dutchess and Suffolk counties may be possessed at any season in Greater New York for consumption, but not for sale. Ducks, geese, brant, and swans may be possessed during the open season and until March 1. On Long Island ducks, geese, and swans may be possessed from October 1 to March 1 and brant until May 1.

North Carolina: Local restrictions in Brunswick, Cabarrus, Craven, Harnett, Mecklenburg, New Hanover, Pender, Rutherford, and Scotland counties.

North Dakota: Deer, quail, partridge, ruffed grouse, prairie chicken, pinnated grouse, sharp-tailed (white-breasted) grouse, Hungarian partridge, English or Chinese pheasants.

Permitted: Hides of big game lawfully taken may be sold at any time. Domesticated game may be sold on written permission of the game board of control.

Ohio: All game protected by the State, except rabbits.

Oklahoma: All game protected by the State.

Permitted: Domesticated game animals and birds, and heads, hides, and horns of big game lawfully killed may be sold.

Oregon: Deer, elk, moose, sheep, antelope, silver-gray squirrel, quail, bobwhite quail, partridge, Hungarian partridge, English partridge, grouse, ruffed grouse, capercailzie, moor hen, pheasant (silver, golden, copper, green Japanese, Reeves, and ringneck), wild turkey, woodcock, upland plover, rail, duck, swan.

Permitted: Five deerskins, properly tagged, may be sold in a season by the hunter who originally secured them. Tags not issued after first five days of close season. Live ringneck pheasants and other birds raised in captivity for breeding purposes may be sold after being pinioned.

Pennsylvania: Deer, quail, ruffed grouse (pheasant) taken in the State; wild turkey, Hungarian partridge, and woodcock (wherever taken).

Permitted: Squirrel, rabbit or hare, bear, dove, reedbird, blackbird, upland plover, curlew, tatler, sandpiper, Wilson or jack snipe, or other shore bird, coot, or mud hen, rail, duck, goose, brant, swan, loon, and grebe taken in the State and ruffed grouse taken outside the State may be sold during the open season and thirty days thereafter. Game or birds used for propagating purposes may be sold at any time under authority of game commissioners.

Rhode Island: Quail, ruffed grouse, pheasant, woodcock.

South Carolina: Quail or partridge taken in the State, until February 20, 1912; Mongolian or other pheasant, wild turkey, and woodcock taken in the State, until March 1, 1911.

South Dakota: All game protected by the State, except dove, golden and upland plover, and woodcock.

Permitted: Hides of big game lawfully killed may be sold at any time. Game or game birds raised in captivity may be sold under written permission of state game warden.

Tennessee: Dyer County—Wild turkey.

Permitted: All game may be sold in the State during the open season and five days thereafter.

Texas: All game animals, hides and horns, wild birds, and wild fowl found in the State.

Utah: Deer, elk, antelope, sheep, quail, partridge, grouse, prairie chicken, sage hen, pheasant, Mongolian, Chinese, and English pheasant, dove.

Permitted: 25 in all of shorebirds and waterfowl may be sold in a day to private parties.

Vermont: Quail, ruffed grouse, pheasant, English partridge, plover, English snipe, woodcock, duck, goose.[a]

Virginia: Quail or partridge, grouse or pheasant, robin, woodcock.

Clarke County—Rabbit, squirrel, wild turkey (outside of county).

Frederick, Shenandoah counties—Wild turkey (prohibition applies only to nonresidents of Virginia).

Washington: All game protected by the State.

Permitted: Hides and horns of big game legally killed, and propagated game animals and birds may be sold at any time.

West Virginia: All game protected by the State.

Wisconsin: All game protected by the State, except rabbit, squirrel, coot (mud hen), and rail.

Permitted: Domesticated deer, moose, elk, and caribou may be sold under permit of state fish and game warden.

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[a] Game from private game preserves stocked at owner's expense may be sold at any time.

Sale of Game Prohibited throughout the Year—Continued.

Wyoming: Deer, elk, moose, antelope, sheep, or any head, hide, scalp, tusk, carcass, or part of carcass thereof, mounted specimens of game or birds, and skins of birds.

Permitted: Sale of 1 live game animal, 1 skin, 1 mounted head, 1 mounted specimen, 1 pair of tusks, 1 hide, 1 scalp, and 1 head of any big game, except moose, on affidavit that they were lawfully captured or were taken from animals lawfully killed and payment of 25-cent fee to the justice of the peace of precinct where affiant lives and attachment of tag issued by him. Sale of the natural increase of any big game, except moose, captured and held for propagation.

Alberta: All game.

Permitted: The flesh of big game and game birds may be sold at any time under $10 license. Heads of big game before being sold must be stamped by minister of agriculture at fees of $5 for elk, caribou, moose, and sheep, and $2 for deer, antelope, and goat.

British Columbia: Elk, quail, grouse, ptarmigan, prairie chicken, English partridge, pheasant, swan, female and young of deer, moose, caribou, or sheep, heads of moose, caribou, and sheep.

Permitted: Male deer after September 1; male moose, caribou, sheep, goats, and hares after October 1; and snipe, plover, and ducks may be sold during the open season and five days thereafter. Lieutenant-governor in council may alter or extend sale seasons of Columbia deer, and all game birds except swans.

Manitoba: Deer, elk, moose, caribou, antelope (except heads and hides), quail, grouse, pheasant, partridge, prairie chicken, woodcock, plover, snipe, sandpiper. Ducks can not be sold before October 1.

Permitted: Possession of grouse, prairie chickens, and partridges allowed for forty-five days, and of ducks for three months, after close of hunting season. Deer for private use may be possessed at any time on proof of legal killing.

New Brunswick: Partridge to September 15, 1912.

Permitted: Geese and brant may be sold during the open season, and until March 1, and all other game during the open season and (under license from game warden) ten days thereafter. Keepers of hotels, inns, boarding houses, or restaurants may serve game during open season and 15 days thereafter. Surveyor-general may issue $1 licenses to dealers permitting sale by each of 3 deer and heads of same to taxidermists, and licenses to deal in hides or skins of game animals with fees of $25 to nonresidents and $2 to residents.

Newfoundland: Capercailzie, black game.

Permitted: Caribou may be sold from August 1 to January 1.

Nova Scotia: Deer, caribou to 1912, pheasant, blackcock, capercailzie, Canada grouse (spruce partridge), chukar partridge.

Permitted: Moose may be sold from September 16 to December 1. Any game bird other than those above mentioned during the open season with the exception of the first three days.

Ontario: Quail, partridge, woodcock, snipe, subject to regulations of lieutenant-governor in council.

Permitted: All other native game may be sold during the open season [a] by the person killing it and by dealers during open season and until the following January 1 under license. Imported game may be sold under special regulations and licenses.

Quebec:[b] Birch or swamp partridge, woodcock, until October 1, 1910.

Permitted: All other game may be sold during the open season and fifteen days after the close thereof. Hotels, restaurants, and clubs may serve, under license, all game lawfully taken, except birch or swamp partridge and woodcock. Live animals, and skins and heads of animals lawfully taken, may be sold.

Saskatchewan: Sheep, goat, or prairie chicken, grouse, pheasant, ptarmigan, or other member of the Gallinæ, unless captured by the owner.

Yukon:

Permitted: Deer, elk, moose, caribou, bison, musk oxen, sheep, and goats may be sold during the open season and sixty days thereafter.

LIMITS.

Laws limiting the amount of game which can be killed in a day or a season are of comparatively recent origin. One of the first statutes of the kind was that passed in Iowa in 1878 (ch. 156, sec. 3) limiting the killing or possession of prairie chickens, snipe, woodcock, quail, and ruffed grouse to 25 in a day.[c] Maine, in 1883 (ch. 185, sec. 1), limited the number of big game which an individual might kill in a season to 1 moose, 2 caribou, and 3 deer; and New York, in 1886 (ch. 194, sec. 1), likewise limited the number of deer to 3. In the last thirty years laws of this kind have been generally adopted and are now in force in all except 7 States. In spite of the objection often urged against such statutes—that they are impossible of enforcement and easily evaded—experience has shown them to constitute one of the most effective features of modern game legislation. They have been tested in the courts and upheld by the supreme courts of several States, notably those of Maine and Wisconsin.[a]

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[a] Seasons depend on regulations of game commission.

[b] Lieutenant-governor in council may prohibit sale of any game for 3 years or less or prolong any existing period of prohibition for 3 years or less.

[c] This statute was, however, preceded by one enacted in 1874 limiting the shipment of game birds to one dozen a day, provided the birds were not shipped for sale (ch. 69, sec. 1).

When restrictions on limits are extended to possession and shipment as well as killing, and the total amount of game allowed a party made less than the quantity allowed the individual members of the party, little difficulty is experienced in enforcing the statute. Moreover, among law-abiding sportsmen the incentive to make large bags is removed when the act is declared illegal.

In recent years bag limits have been materially reduced, and only a few States now allow more than 2 deer a season or 1 head of other big game, while the usual limits per day in the case of birds are 10 grouse or woodcock, 15 quail, and 25 waterfowl. In Canada, where the country is not so closely settled, bag limits on birds are fewer and those on big game more liberal than in the United States.

Limits fixed by Law for the Capture of Game.

Alabama: One deer, 2 turkeys, 25 of each other kind of birds a day.

Alaska: Two moose, 3 each of caribou, sheep, and brown bears a season; 25 grouse, ptarmigan, shore birds or waterfowl a day.

Arizona: Three deer a season, 25 quail a day.

Arkansas: No limits, except in the following counties: Deer, Bradley 3, Dallas 3, Desha 4, Phillips 4 (or 1 for each member of party), Chicot 5 a season; quail, Bradley and Dallas 300 a season or 25 a day for each member of party.

California: Two deer a season; 20 each of quail, doves, plover, curlew, snipe, shore birds, rail, and ibises, and 25 ducks and black sea brant a day.

Colorado: One deer a season; 20 of each kind of game bird a day, 25 ducks, 25 geese, and 25 of all other birds in possession at one time. Any person under 12 years of age is limited to one-half this number of birds.

Connecticut: Five each of quail and ruffed grouse a day, 36 a year; 35 rail, 50 each of plover, snipe, shore birds a day.

Delaware: No limits.

District of Columbia: No limits.

Florida: Five deer, 5 turkeys a year; 20 quail, 2 turkeys by individual, or 40 quail, 4 turkeys by party a day.

Georgia: Forty doves a day.

Idaho: Two deer, 1 elk, 1 ibex, 1 goat, 1 sheep a season; 18 quail, 12 each of partridges, sage hens, grouse, pheasants, plover, snipe, 24 doves, ducks, 4 geese, 1 swan a day, but not more than 24 of all kinds a day.

Illinois: Fifteen squirrels; 12 quail, 15 doves, 15 woodcock, 15 shore birds, 20 coots, 20 rail, 15 ducks, 10 geese, 10 brant, 20 other waterfowl a day.

Indiana: Fifteen quail; 15 ducks or other waterfowl a day; 45 birds in possession as result of 3 or more days' consecutive hunting.

Iowa: Twenty-five each of all animals, birds, and game a day; 50 ducks in possession at one time.

Kansas: Twenty each of quail, plover, duck; 15 each of grouse, prairie chickens; 10 each of geese and brant a day.

Kentucky: No limits.

Louisiana: Two deer a day, 6 a season; 25 birds a day.

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[a] See Allen *v.* Leighton, 32 Atl., 877 (Maine, 1895); State *v.* Nergaard, 102 N. W., 899 (Wisconsin, 1905).

Limits fixed by Law for the Capture of Game—Continued.

Maine: One moose, 2 deer a season (except in Cumberland, Knox, Kennebec, Lincoln, Sagadahoc, Waldo, and York counties, limit 1, and in lumber camps, limit 6); 15 each of ruffed grouse, plover, snipe, woodcock, and ducks, and 70 sandpipers a day.

Maryland: No limits.

Massachusetts: No limits.

Michigan: Two deer a year; 12 each of quail, grouse, spruce hens a day, 50 in possession at a time; 25 plover, snipe, woodcock, ducks, waterfowl a day, 75 in possession at a time.

Minnesota: One deer (nonresident), 2 deer (resident), 1 moose a season, 15 birds a day; 45 quail, partridges, ruffed grouse, pheasants, prairie chickens, white-breasted or sharp-tailed grouse, doves, plover, woodcock combined; 50 snipe, duck, goose, brant, any aquatic fowl combined, in possession at a time.

Mississippi: One deer a day, 5 in a season; 20 each of quail, wild turkeys, plover, tatlers, chorooks, grosbecs, coots, poules d'eau, rails, ducks, geese, brant, swans a day.

Missouri: One deer, 2 turkeys, 25 of any other species a day; or 2 deer, 4 turkeys, 50 of any other species in possession at a time.

Montana: Three deer, 1 elk, 1 goat, 1 sheep a season; 5 each of grouse, partridges, prairie chickens, fool hens, pheasants, sage hens, and 20 ducks a day.

Nebraska: Ten squirrels, 10 geese or brant, 25 other birds a day; 10 geese or brant, 50 other birds and 20 squirrels in possession at a time.

Nevada: Two deer, 2 antelope a season; 15 mountain quail, 15 valley quail, 10 sage hens, 6 grouse, 5 plover, and 15 snipe, 20 ducks, 10 geese, 3 swans a day.

New Hampshire: Two deer a season.

New Jersey: One deer a season; 30 marsh hens a day.

New Mexico: One deer a season; 2 wild turkeys a day, 4 in possession at one time; 6 grouse a day or in possession at one time; 20 ducks a day, 30 in possession at one time; 30 other birds a day or in possession at one time.

New York: Two deer, 36 quail, 36 woodcock, 20 grouse, 3 male imported pheasants a season; 6 quail, 6 woodcock, 4 grouse a day.

North Carolina: Dare County, 5 deer a season; Brunswick, New Hanover, and Pender counties, 15 marsh hens a day; Buncombe County, 2 deer a season, 25 partridges, pheasants, wild turkeys, or doves; Cabarrus County, 15 quail or partridges; Madison County, 25 birds; Transylvania County, 10 squirrels, 20 quail or partridges a day.

North Dakota: Two deer a season; 10 prairie chickens, grouse, doves, cranes, swans combined a day, 20 in possession at one time; 25 plover, snipe, woodcock, ducks, geese, brant combined, 50 in possession at one time.

Ohio: Twelve each of quail, doves, plover, snipe, woodcock, shore birds, rail, geese; 25 ducks a day.

Oklahoma: One deer a season; 1 turkey (male) March 15–April 15, 3 turkeys, November 15–January 1; 25 quail, plover, curlew, snipe, other shore birds, or ducks a day, 150 a season; 15 prairie chickens a day, 100 a season, 10 geese or brant a day; 1 swan a season.

Oregon: Five deer a season; 5 each of quail, prairie chickens, sage hens a day, 10 a week (10 quail a day 20 a week, in Jackson and Josephine counties); 5 grouse, ruffed grouse, partridges, native and imported pheasants a day, taken collectively, 10 a week; 50 shore birds, 25 ducks a week.

Pennsylvania: One deer a season; 6 squirrels, 10 rabbits or hares a day; 10 quail a day, 40 a week, 75 a season; 5 ruffed grouse a day; 10 each of English, Mongolian, or Chinese pheasants and woodcock a day, 20 a week, 50 a season; 1 wild turkey a day, 2 a season. Possession limited to season's limit.

Rhode Island: No limits.

South Carolina: No limits.

South Dakota: Two deer, 1 elk, 1 buffalo, 1 sheep a year; 20 waterfowl, 10 other birds a day; 25 partridges, ruffed grouse, prairie chickens, sharp-tailed (white-breasted) grouse, pheasants, woodcock, golden plover and upland plover, in aggregate in possession at one time; 50 snipe and waterfowl in aggregate in possession at one time.

Tennessee.—Fifty ducks; 30 of all other birds in aggregate a day.

Texas.—Three deer a season; 25 birds a day (3 wild turkeys December to February).

Utah.—One deer a season (residents only), 15 quail, 8 sage hens, 25 doves a day or in possession at one time, 5 in all of geese, brant, and swans a day, and 25 in all of snipe, shore birds, ducks, geese, brant, swans a day (having more than 25 in possession at one time prima facie evidence of violation of law).

Vermont.—One deer and 25 ruffed grouse or woodcock a season; 5 each of gray squirrels, quail, ruffed grouse, pheasants, plover, English snipe, woodcock, geese, and 20 ducks a day.

Virginia.—No limits.

Washington: Two deer, 2 sheep, 2 goats, 1 moose, 1 antelope, 1 caribou, a season; 5 in all of partridges, grouse, prairie chickens, and pheasants, 10 quail a day; 20 in all of snipe, ducks, geese, and brant a day or 50 a week. If the bag of upland game birds includes quail the limit is 10 a day or 30 a week.

West Virginia.—Two deer a season; 12 quail a day, 96 a season; 6 ruffed grouse a day, 25 a season; 2 wild turkeys a day, 6 a season.

Wisconsin.—One deer a year; 10 grouse, prairie chickens, woodcock; 15 partridges; 25 plover, snipe, coots, rail, ducks; 10 geese or brant a day.

Limits fixed by Law for the Capture of Game—Continued.

Wyoming.—Two deer, 1 elk (1 additional under special license), 1 sheep a season; 18 birds (of which not more than 12 may be grouse) a day, or in possession at one time.

Alberta.—One deer, 1 moose, 1 caribou, 2 antelope, 2 sheep, 2 goats a season; 20 grouse, partridges, pheasants, prairie chickens, ptarmigan a day, or 200 a season.

British Columbia.—Five deer, 2 elk (nonresident 1), 2 moose (1 in county of Kootenay), 3 caribou, 3 goats, 2 sheep (1 in county of Kootenay), 250 ducks and snipe a season.

Manitoba.—One in all of deer, elk, moose, caribou, and antelope a season; 20 in all of grouse, partridges, prairie chickens a day, 100 a season; 20 ducks a day in September, 50 ducks a day in October and November.

New Brunswick.—Two deer, 1 moose, 1 caribou a season (lumber camp limited to 2 moose, 2 caribou a season).

Newfoundland: Three caribou a season.

Nova Scotia: One moose a season; 5 ruffed grouse, 15 woodcock a day.

Ontario: Two deer, 1 moose, 1 caribou a season. Two or more persons hunting together under license may kill an average of 2 deer each.

Prince Edward Island: No limits.

Quebec: Zone 1: 2 deer, 1 moose, 2 caribou a season. Zone 2: 2 deer, 1 moose, 4 caribou a season.

Saskatchewan: Two deer, 2 elk, 2 moose, 2 caribou, 2 antelope a season; 10 grouse, partridges, pheasants, prairie chickens, ptarmigan a day, or 100 a season.

Yukon: Six caribou or deer, 2 moose, 2 elk, 2 sheep, 2 goats, 2 musk oxen a season.

LICENSES FOR HUNTING AND SHIPPING GAME.

In Arkansas nonresidents are not permitted to hunt, except on their own premises,[a] and in all the States except Georgia and throughout Canada licenses must be secured before nonresidents can hunt any or certain kinds of game (see fig. 2, p. 4). In 32 States and 5 Canadian Provinces a like restriction is imposed on residents, but the fees are usually very much smaller, and often are merely nominal (see fig. 1). The fees for nonresident licenses for both big and small game range from $10 in a number of States to $50 in Alaska, Wyoming, New Brunswick, and Newfoundland, and $100 in British Columbia, Saskatchewan, and Yukon; those for resident licenses from 50 cents in Vermont to $5 in Missouri and Washington, and $7 ($5 for moose and caribou and $2 for deer) in Ontario.

A special kind of hunting license, often known as the "alien" license, is being generally adopted to restrict hunting by persons who are not citizens of the country and is now in force in about half of the States. Maine, Massachusetts, Connecticut, and Rhode Island have special $15 licenses for resident aliens, Washington, Wyoming, and Manitoba a $50 license for nonresident aliens, California, Idaho, Montana, and Nevada a $25 license, Utah and Alaska a $100 license for all aliens, and Pennsylvania prohibits aliens from hunting or owning guns in the State.

Licenses are generally issued only for the open season, and thus expire at fixed dates. Some are necessarily very brief in duration. Michigan issues a $25 nonresident deer license good only for twenty days in November; Vermont, a $15 nonresident deer license good only for the last six consecutive week days of October. In a few instances licenses are issued at reduced rates for a week or for a few days. Of this character are the nonresident bird licenses, good for one week, issued by Colorado and British Columbia; the guest licenses, good for five days, issued by Alberta and Saskatchewan; and the daily and weekly licenses issued for hunting birds in Colorado and any game in Lafayette and Sumter counties, Fla.

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[a] Except in western district of Clay County under a $15.50 license, and in Bradley, Dallas, Desha, Phillips, and Stone counties, under invitation of licnesed resident.

Landowners or taxpayers are not required to pay the usual fee in a number of States,[a] and no license is required of those hunting in their own county in Minnesota, Nebraska, Texas, or Nova Scotia, Special exemptions are made in favor of nonresident members of fish and game clubs by Kansas, Massachusetts, Rhode Island, and Quebec. In Virginia no license is required of bona fide guests of residents, and in Ontario no fee is charged for a guest license.

In Maine,[b] South Dakota, Wyoming, New Brunswick (on wild lands), and Nova Scotia nonresidents are not permitted to hunt big game unless accompanied by qualified guides. Nearly every State requires licensees to have their licenses in personal possession while hunting and to exhibit them on demand of any warden (in New Hampshire and New York of any person).[c]

Details in regard to hunting licenses are given in the following table. In every case the fee includes the amount charged for issuing the license by the county clerk or other officer.

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[a] All the counties of Maryland allow nonresidents to hunt without license on invitation of landowners, except Allegany, Caroline, Dorchester, Garrett, Kent, Somerset, Talbot, and Worcester. (Dorchester grants the privilege if the nonresident be a relative of his host.)

[b] On wild lands of the State, except from December 1 to 15.

[c] The following counties in North Carolina require hunters to obtain written permission for hunting on lands other than their own: Buncombe, Carteret (Morehead Township), Catawba, Cherokee, Clay, Cleveland, Craven, Currituck, Davidson, Harnett (Averysboro and Grove townships), Henderson, Hertford, Iredell, Jones, Madison, Martin (Cross Roads, Goose Nest, Hamilton, and Poplar Point townships), Pender, Polk, Randolph (townships of Back Creek, Franklinsville [quail], and New Hope), Richmond (Mineral Springs, Steele, Wolfpit townships), Robeson, Rowan, Rutherford, Transylvania, Union, Wayne, and Yadkin.

Details of Hunting Licenses and Export Regulations.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Alabama	Nonresident	$15.00	Probate judge	Expires Dec. 31	Nonresident licensee may carry out of State or have carried to him game lawfully killed by him.
	Alien	15.00	do	do	
	Resident	3.00	do	State license; required outside of county of residence, except on lands owned or leased by hunter.	
	do	1.00	do	County license; except on lands owned or leased by hunter. Expires Dec. 31.	
Alaska	Nonresident	50.00	Governor	Expires Dec. 31	2 moose (north of lat. 62°), 4 deer, 3 caribou, 3 sheep, 3 goats, and 3 brown bears.
	Alien (nonresident)	100.00	do	do	
	Guide		do	American citizen or native of Alaska. Fee fixed by governor.	
	Shipping (resident)[a]	40.00	do	Export of heads or trophies by resident	1 moose (north of lat. 62°), 4 deer, 2 each of caribou, sheep, goats, and brown bears.
	do	10.00	do	do	1 caribou or sheep.
	do	5.00	do	do	1 deer, goat, or brown bear.
	Shipping (special)[a]	150.00	do	Export of moose from southern Alaska	1 moose, south of lat. 62°.
Arizona	Nonresident	10.00	Game commissioner or county recorder.	Deer only	No export.
Arkansas				Nonresidents not permitted to hunt[b]	Do.
California	Nonresident	10.00	Game and fish commissioners, county clerks.	Expires June 30	Do.
	Alien	25.00	do	do	
	Resident	1.00	do	do	
Colorado	Nonresident or alien	10.00	Commissioner of game	Expires Dec. 31	Permit required from commissioner.
	do	2.00	County clerk	County license for birds, good for one week	
	do	1.00	do	County license for birds, good for one day	
	Resident	1.00	Commissioner of game or county clerk.		
	Guide	5.00	Commissioner of game	Must also have state license	
Connecticut	Nonresident	10.25	City, town, or borough clerk.	Expires Dec. 31	No quail, ruffed grouse, or woodcock.
	Alien	15.25	do	do	
	Resident (citizen)[c]	1.25	do	do	
Delaware	Nonresident	10.00	Delaware Game Protective Association.		No rabbit, quail, partridge, woodcock, Wilson snipe.
Florida	Noncitizen[d]	10.00	Clerk of circuit court	County license. Expires Mar. 1	No deer, quail, or wild turkeys.
Georgia	Market hunting	25.00	Ordinary of county	County license. Expires Dec. 31	No quail.
Idaho	Nonresident or alien	25.00	Warden, probate judge, or justice of peace.	Expires Mar. 31	2 deer, 1 ibex, 1 mountain goat, 1 mountain sheep, 1 elk. No birds.
	do	5.00	do	Birds only	
	Resident citizen	1.00	do	Not required of women	

Illinois	Nonresident	25.50	City, village, or county clerk.	Expires June 1	Not more than 50 birds of all kinds.
	Resident	1.00	.....do	Not required of owners and tenants of farms hunting on their lands.	
Indiana	Nonresident	15.50	Clerk of circuit court	Good for 1 year	15 birds of all kinds, or 45 in case of 3 or more days' consecutive hunting.
	Resident	1.00	Commissioner of fisheries and game, clerk of circuit court.	Not required of landowners hunting on their own lands, nor of their children or tenants, nor for hunting rabbits in township of residence.	
Iowa	Nonresident	10.50	County auditor	Expires July 1	25 of all kinds of game.
	Resident	1.00	.....do	Not required of owners or tenants of farm lands, or their children, hunting on such lands.	
Kansas	Nonresident	15.00	Secretary of state	Not required of landowners and members of clubs hunting on their own premises. Expires June 30.	No export.
	Resident	1.00	County clerk	.....do	
Kentucky	Nonresident		.....do	Fee charged nonresident in State of applicant. Expires 1 year from date of issue.	No quail, grouse, pheasant, wild turkey.
Louisiana	Nonresident	25.00	Tax collector	County license. Required also of unnaturalized foreign-born residents. Good for season.	2 wild turkeys, 25 ducks, and 12 other birds, twice a season.
	Resident	1.00	.....do	State license. Not required of person hunting on his own land.	
Maine	Nonresident	15.00	Commissioners of game	All game during October, November, and December	1 moose, 2 deer, 10 each of partridges, ducks, and woodcock.
	.....do	5.00	.....do	Game that may be shot before Oct. 1. Holder may obtain big-game license by paying $10 additional.	
	Alien	15.00	.....do	Not required of aliens who pay taxes or who have resided in State 2 years continuously prior to 1907.	
	Camp keeper	5.00	.....do		
	Guide (nonresident)	20.00	.....do	Expires Dec. 31. Guide to be registered, and to guide not more than 5 persons at a time.	
	Guide (resident)	1.00	.....do	.....do	
	Shipment		.....do	Moose, $5; deer, $2; pair of game birds, 50 cents. Permits shipping home or to hospital in State.	
Maryland	Nonresident [e]	5.00 25.50	Clerk of circuit court	Separate county laws	Local laws.

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[a] Not more than one general ($40) license and 2 special ($150) moose licenses issued to one person in one year. Each shipper must file with customs office at port of shipment an affidavit that he has not violated the game law; that the trophy to be shipped has not been bought or purchased, has not been sold, and is not shipped for purpose of sale; that he is the owner of the trophy, and, in case of moose, whether the animal from which it was taken was killed north or south of latitude 62°.

[b] But see State *v.* Mallory, 83 S. W. 955, deciding that nonresidents may hunt on their own land. In a few counties nonresidents may hunt under certain conditions (see page 44). Residents are required to obtain licenses in the following counties: Phillips, $1; Bradley, Dallas, $1.50; Chicot, Desha, $2.

[c] No license is required of a bona fide resident of Connecticut, or his lineal descendants, hunting on land occupied by him and used for agricultural purposes.

[d] Not applicable to counties having special game laws. Nonresidents of Lafayette and Sumter counties required to secure license of game warden and pay therefor $1 per day. Hernando County issues a $10 nonresident and a $1 resident license, both good for the season, and Clay County issues a $10 guide license. No one is permitted to hunt in Taylor County who is between the ages of 18 and 60 and does not pay taxes or work on the roads in the county, nor in Wakulla County if between the ages of 21 and 55 and not a taxpayer of the State.

[e] County and local licenses are issued at the following rates, including clerk fees: Allegany, $10.50; Baltimore, $5.25; Calvert, $10.50; Caroline, $5; Carroll (upland game), $10.50; Cecil, $5.50; Charles (rabbit, quail, and woodcock), $20.50 (nonresidents not permitted to shoot waterfowl); Dorchester, $5; Frederick, $15.50; Garrett, $25.50; Harford, $10.50 (all game except waterfowl); Howard, $8; Kent, $15 50 (if invited by landowner, $5.50); Montgomery, $15.50; Patuxent River, $11, club license, $50; Prince George, $20.50 (upland game); Queen Anne, $5; St. Mary, $20.50 (upland game); Somerset, $2.75, nonresident of the State, $10.50; Talbot, $10 (upland game); Washington, $10.50; Wicomico, $10.50; Worcester (wild fowl), $10. Guests of landowners require no licenses, except in Allegany, Caroline, Dorchester, Garrett, Kent, Somerset, Talbot, and Worcester counties. Nonresident taxpayers are usually exempt. Anne Arundel allows hunting by nonresidents only by permission of landowners. In several counties residents pay special licenses as follows: Anne Arundel, pusher, $2, booby and brush blind, $5; Cecil—Elk, and Bohemia rivers, sneak boat, $5.50, sink box, $10.50; Queen Anne, booby blind, $2.50, sink box, $10.50; Susquehanna Flats, sneak boat, $5.75, sink box, $20.75; Patuxent River, pusher, $2.50.

Details of Hunting Licenses and Export Regulations—Continued.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Massachusetts	Alien	15.00	City and town clerk	Required of unnaturalized foreign-born residents	
	Nonresident	a 10.00	Commissioners of fisheries and game.	Expires Dec. 31	6 birds.
	Resident	1.00	City and town clerk	Not required of persons hunting on land which they own or on which they live.	
Michigan	Nonresident	25.00	County clerk	Deer. Good for season	1 deer under shipping permit.
	do	10.00	do	Small game only Not required of persons hunting on their own land.	
	Resident	1.50	do	Deer. Good for season	
	Export	10.00	State game and fish warden.		Nonresident landowner and member of a club maintaining a game preserve may export 50 ducks or migratory birds killed by him on said premises.
Minnesota	Nonresident	25.00	Game commissioners	Game animals. Expires Dec. 31	1 deer, 25 birds.
	do	10.00	do	Game birds	
	Resident	1.00	County auditor	Not required in county of residence	
Mississippi	Nonresident	20.00	Sheriff	County license. Landowners and their nonresident relatives and friends hunting on their lands exempt. Good for season.	No export.
Missouri	do	25.00	Game commissioner	Expires Dec. 31	2 deer, 4 turkeys, 50 of other species.
	Resident	5.00	County clerk or license collector.	State license. Expires Dec. 31	
	do	1.00	do	County license. Required for hunting in county of residence or in adjoining counties. Not required of owners or tenants of farm lands hunting on such lands. Expires Dec. 31.	
Montana	Nonresident or alien.	25.00	Game and fish warden	Expires Dec. 31	Number permitted to be killed (see p. 43).
	do	10.00	do	Birds only	
	Resident b	1.00	Game warden or justice of the peace.		
	Guide	10.00	Game warden	Good for 1 year	
	Shipping	.50	do	Permits limited export in open season	
Nebraska	Nonresident	10.00	Game commissioner or county clerk.	Expires Dec. 31	50 birds.
	Resident	1.00	do	Necessary outside of county of residence	
Nevada	Nonresident	10.00	County clerk or game warden.	Not required of women, of children under 14, or of persons hunting on their own land.	No export.
	Alien	25.00	do	Good for one year	
	Resident	1.00	do	do	
New Hampshire	Nonresident or alien.	10.00	Game commissioners	Expires Dec. 31	2 deer, 12 birds.
	Resident c	1.00	do		

New Jersey	Nonresident	10.50	County clerk	Expires Dec. 31	10 rabbits and 15 birds a day.
	Alien	10.50	County, city, or town clerk.	Not required of owner or lessee of farm land hunting on land on which he resides.	
	Resident citizen	1.00	do.	Not required of land owner or members of family residing on his land and hunting thereon.	
New Mexico	Nonresident	25.00	Territorial game warden or authorized deputy.	Big game	Under permit.
	do.	5.00	do.	Game birds except turkeys	
	Alien	10.00	do.	do.	
	Resident alien	5.00	do.	do.	
	Resident	1.50	do.	General	
	do.	1.00	do.	Big game, including turkeys	
	do.	1.00	do.	Game birds, except turkeys	
	Guide	5.00	do.		
New York	Nonresident	20.50	County, city, or town clerk.	Expires Dec. 31. Alteration of license a forgery	1 deer.
	Alien	20.50	do.	do.	
	Resident	1.10	do.	Alteration of license a forgery. Not required of owner or lessee (or immediate family) occupying and cultivating farm land and hunting on such land.	
North Carolina	Nonresident (Audubon).	10.25	Clerk of superior court	Good only in 46 counties not covered by following license. Not required of parents and children of landowners hunting on their grounds.	50 partridges or quail, 12 grouse, 2 turkeys, 50 beach birds or snipe.
	Nonresident (special).[d]	10.50	do.	Good only in county of issue	
North Dakota	Nonresident	25.00	County auditor	Expires Dec. 15	2 deer; 20 (in all) of grouse, prairie chickens, doves, cranes, and swans; 50 (in all) of plover, snipe, ducks, geese, and brant.
	Resident[c]	1.00	do.		
Ohio	Nonresident	15.25	County clerk	Expires Dec. 5	50 animals and birds.
Oklahoma	Nonresident	15.00	Warden or county clerk	All game except deer, turkeys, and prairie chickens. Expires May 1.	2 days' bag limit.
	Alien	25.00	do.	do.	
	Resident citizen	1.25	do.	Not required of minor under 14 years, or person hunting on his own or leased lands.	
Oregon	Nonresident	10.00	County clerk	Not required of landowners hunting on their own premises. Good for one year.	No export allowed, except by Washington hunters, who may take one day's bag.
	Resident	1.00	do.	do.	
Pennsylvania	Nonresident	10.00	County treasurer	Good for year of issue. Aliens not permitted to hunt	1 day's bag limit.

[a] Members of incorporated game clubs owning real estate assessed at not less than $1,000 and organized prior to 1907, owners of real estate assessed at not less than $500, or nonresidents invited (for not more than 4 days) by members of incorporated club for hunting foxes, pay a fee of $1.

[b] United States soldiers stationed in the State and officers of the United States forest service classed as residents.

[c] Not required of owner or occupant of agricultural lands or members of his immediate family hunting on such lands.

[d] Issued in the following 52 counties: Beaufort, Bertie, Camden, Carteret, Caswell, Chowan, Clay, Cleveland, Currituck, Davie, Duplin, Franklin, Forsyth, Gaston, Gates, Graham, Harnett, Henderson, Hertford, Hyde, Jackson, Johnson, Jones, Lincoln, Madison, Macon, Mitchell, Montgomery, Nash, Onslow, Pamlico, Pasquotank, Perquimans, Pitt, Pender, Polk, Randolph, Richmond, Robeson, Sampson, Stokes, Stanly, Swain, Tyrrell, Union, Vance, Warren, Washington, Wayne, Wilkes, Wilson, Yadkin. Residents of counties having no open season are required to obtain a $10 license when hunting in Gaston or Lincoln county. In Dare County, $25 license is required for shooting wildfowl from blind, battery, box, float, or raft in waters lying north of a line passing through northern end of Roanoke Island; south of said line 2 nonresidents may shoot from such devices belonging to a resident if a $5 tax has been paid upon same.

Details of Hunting Licenses and Export Regulations—Continued.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Rhode Island	Nonresident[a]	10.15	City or town clerk	Expires Dec. 31	10 birds.
	Alien	15.15	do		
	Resident	1.15	do	Not required of owner or occupant of agricultural lands or members of his immediate family hunting on such lands.	
South Carolina	Nonresident	10.25	County clerk	All game except quail and wild turkeys. Required of nonresidents and aliens. Good for season.	2 deer, 4 wild turkeys, 12 ruffed grouse, 50 each of partridges (quail), beach birds, ducks, geese.
	do	25.00	do	County license for quail and wild turkeys. Not required of person hunting on land owned or controlled by him or when guest of and accompanied by resident freeholder.	
	Market hunting	50.00	County treasurer	County license for residents hunting wild fowl on public lands and navigable waters. Expires Dec. 31.	
South Dakota	Nonresident	25.00	Warden or county treasurer.	Big game and game birds. Expires June 30	Birds lawfully in possession.
	do	15.00	do	Game birds only	
	Resident	1.00	do	Not required of landowner hunting on his own property.	
Tennessee	Nonresident	10.25	State game warden	Not required of property owners who pay $100 in taxes. Expires Dec. 31.	50 ducks; 30 of all other birds in aggregate.
	Resident	3.00	do	Required when hunting on lands with verbal permission of owner.	
	Market hunting	25.00	do	Annual license; $200 bond required	
Texas	Noncitizen	15.00	Game commissioner	Expires Dec. 31	1 day's bag limit.
	Resident	1.75	County clerk	Not required in county of residence or adjoining counties or on land controlled by hunter. Expires Sept. 1.	
Utah	Nonresident	5.00	Game commissioner or deputy; justice of the peace.	Expires Dec. 31	1 day's bag limit.
	Alien	100.00	do	do	
	Resident	1.25	do	Not required of females or children under 12	
Vermont	Nonresident[b] or alien	15.00	Town clerk	Deer. Expires Sept. 1	1 deer; birds as stated on p. 35.
	Nonresident[b]	[c] 5.00	do	Birds only. Expires Sept. 1	
	Resident	.50	do	Not required of owners or tenants of farm lands, or their children, hunting on such lands.	
Virginia	Nonresident[d]	10.00	County clerk	Good in open season in the 6 months following issue	1 deer, 50 quail, 10 pheasants or grouse, 3 wild turkeys, 30 waterfowl, 25 of each or 100 in all, plover, snipe, sandpipers, willets, curlew, and tattlers.
Washington	Nonresident	10.00	State auditor	State license. Good for 1 year	A season's limit of big game and a day's limit of birds.
	do	5.00	State or county auditor	County license	
	Alien, nonresident	50.00	do	State or county license	
	Resident	5.00	State auditor	State license	
	do	1.00	State or county auditor	County license	

West Virginia	Nonresident or alien.	15.50	County clerk	Good for 1 year	No deer, quail, ruffed grouse, pheasants, wild turkeys.
	Resident	1.00	....do	Not required of landowners hunting on their own property.	
Wisconsin	Nonresident	25.00	Secretary of state	All game	1 deer, 30 birds.
	....do	10.00	....do	All game except deer	
	Resident [e]	1.00	County clerk		
Wyoming	Nonresident or alien.	50.00	Justice of the peace	Each licensee must employ guide. Expires Dec. 31	2 elk, 2 deer, 1 sheep, 20 game birds.
	Nonresident	50.00	....do	1 additional elk	
	....do	5.00	....do	Birds only	
	Alien	20.00	....do	....do	
	Resident [f]	2.50	....do	Ordinary	
	....do	17.50	....do	1 additional elk	
	....do	1.50	....do	Birds only	
	Guide [g]	10.00	....do		

CANADA.

Alberta	Nonresident	25.00	Minister of agriculture	Expires Dec. 31	Under general license, trophies of big game legally killed.
	....do	15.00	....do	Birds only. Expires Dec. 31	
	Guest	2.00	Game guardian	Guests of residents. Good for 5 days	
	Guide, camp help	5.00	Minister of agriculture	Resident maximum fee. Expires Dec. 31	
	Resident [h]	2.50	....do	Big game. Expires Dec. 31	
	Market hunting	10.00	....do	Expires Dec. 31	
British Columbia	Nonresident	100.00	Game warden or any government agent.	Members of army or navy or Canadian militia in actual service exempt.	Heads, hides, and horns of animals legally killed by licensees.
	....do	25.00	....do	Deer, goat, bear. Good for 1 month	
	....do	25.00	....do	Bear in spring	
	....do	5.00	....do	Birds only. Good for 1 week	
Manitoba	Nonresident	50.00	Minister of agriculture	Expires Dec. 31	2 heads and skins each species of game animal, 50 ducks, 100 geese, or swans, and any other game bird, except partridge, grouse, and prairie chicken under permit of Minister of agriculture.
	....do	10.00	....do	British subject	
	Resident	2.00	....do	Big game only	
	....do	1.00	....do	Birds only. Required of resident of city, town, or incorporated village.	

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[a] Nonresident citizens and members of hunting or fishing clubs incorporated prior to January 1, 1909, owning real estate to the value of $1,000, and nonresident citizens owning real estate assessed at not less than $500, pay a fee of $1.15.

[b] Not required of anyone owning real estate in Vermont, occupying the same as a domicile at least 3 months in the year, and paying taxes thereon.

[c] A nonresident holding a bird license may secure a deer license by paying $10 additional.

[d] Guests not required to procure license to hunt on land of host, provided the host receives no compensation, directly or indirectly, from such guest and hunts with him.

[e] Bona fide settler who has not resided in the State 1 year may take out a special resident license.

[f] Applicant must be an elector of the State; child or ward, over 14 years, of an elector; or a soldier or sailor of the United States and an elector thereof, stationed 1 year at a post in the State. Soldier or sailor must employ guide.

[g] Guide must be citizen and qualified elector of State, must act as assistant game warden, and is equally responsible with employer for violation of law.

[h] Not required in northern Alberta.

Details of Hunting Licenses and Export Regulations—Continued.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
New Brunswick	Nonresident	50.00	Surveyor-general	Moose, caribou, and deer[a]	No partridge; other game under permit.
	do	25.00	do	Special license for Westmoreland County	
	do	10.00	do	2 deer only. Discretionary with surveyor-general	
	do	10.00	do	Game birds	
	Resident	2.00	do	Moose, caribou, and deer	
	do	.25	do	In Westmoreland County	
	Guide	1.00	do	Resident accompanying anyone hunting big game	
	Camp help	1.00	do	Resident	
	do	50.00	do	Nonresident	
Newfoundland[b]	Nonresident	51.00	Stipendiary magistrate; justice of the peace; minister of marine.	Good for season. Licensee can not employ unlicensed guide.	3 caribou under license and permit.
	Guide	50.00	do	Nonresident. Resident guide licenses free	
Nova Scotia[c]	Nonresident	30.00	Provincial secretary, game commissioners.	Expires Aug. 1. Must employ licensed guide	1 moose lawfully killed by licensee.
	Resident	5.00	do	For shooting woodcock and English snipe outside county of residence. Expires Aug. 1.	
	Guide	2.00	do	Resident. Expires Aug. 1	
Ontario	Nonresident[d]	50.00	Superintendent of game		2 deer, 1 bull moose, 1 bull caribou lawfully killed by licensee.
	Resident	5.00	do	Moose and caribou	
	do	2.00	do	Deer	
	Guest		do	No fee required. Good for 1 week or less	
	Nonresident	25.00	do	Ducks and other small game	100 ducks lawfully killed by licensee.
	Guide	2.00	do	Maximum fee	
Prince Edward Island.	Nonresident[e]	15.00	Game inspector	All game. Expires 1 year after date	12 birds (except geese and brant, on which no limit is placed).
Quebec	Nonresident	25.00	Minister of colonization, or his agents.	All game	
	do	10.00	do	Issued to members of incorporated hunting clubs	
	Resident	1.00	do	Big game. Not required of person hunting for his own use.	
	Resident[f]	5.00	do	3 deer and 3 caribou additional to bag limit	
Saskatchewan	Nonresident	100.00	Game guardian	Expires Dec. 31	Under general license, trophies of big game legally killed.
	do	50.00	do	Birds only. Expires Dec. 31	
	Guest	1.00	do	Guests of residents. Good for 5 days	
Yukon	Nonresident	100.00	Commissioner of Territory or game guardian.	Big game only	Under permit only.

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[a] Nonresidents hunting big game must be in charge of registered guide.

[b] Any officer of a British war ship stationed on the coast of Newfoundland for fisheries protection may obtain a free hunting license good for 6 weeks of open season and may employ an unlicensed guide.

[c] Nonresident landowners paying $30 or more annual taxes and officers of the army or navy stationed in Nova Scotia pay $5 fee.

[d] Lieutenant-governor in council authorized to reduce license fees charged residents of other provinces to rates corresponding with those residents of Ontario are required to pay in such provinces.

[e] Nonresidents paying taxes on real estate in Prince Edward Island to value of $325 pay a fee of only $5.

[f] No fee required of poor Indians or settlers, in discretion of Minister of colonization, mines, and fisheries.

APPENDIX.

TABLES SHOWING OPEN SEASONS FOR GAME UNDER COUNTY LAWS.

In several States local laws prevail to such an extent as to require special tables. The county laws of Virginia and Tennessee were repealed in 1903 and those of Alabama in 1907, but local laws are still the rule in Maryland and North Carolina. In California, under the county government act of April 1, 1897, boards of supervisors were authorized to shorten the open seasons for game. In July, 1905, the district court of appeals of the second appellate district, in passing on the constitutionality of the dove ordinance of Los Angeles County (Ex parte Prindle, 1 Cal. App. Dec., 280; 94 Pac., 871), declared this authority abrogated by an amendment to the constitution adopted in 1902. Consequently these local seasons are not here included.

In the following table the season for each kind of game under the State law (if any) is first given, after which the local exceptions are stated by counties:

MARYLAND.

Open Seasons for Game under County Laws.[a]

Kinds of game.	Open seasons.
Deer:	
Allegany	Oct. 15-Jan. 1.
Baltimore	Sept. 1-Jan. 1.
Garrett	Oct. 1-Jan. 1.
Washington	Nov. 1-Jan. 2.
Rabbit:	
Allegany, Dorchester	Nov. 1-Jan. 1.
Anne Arundel, Queen Anne.	Nov. 15-Dec. 24.
Baltimore	Nov. 10-Dec. 25.
Baltimore City (sale), Frederick, Kent.	Nov. 1-Dec. 24.
Calvert	Nov. 5-Dec. 24.
Caroline, Wicomico, Worcester.	Nov. 15-Jan. 15.
Carroll, Howard	Nov. 10-Dec. 24.
Cecil	Oct. 25-Dec. 24.
Charles	Oct. 15-Jan. 15.
Garrett	Nov. 1-Feb. 1.
Harford, Washington	Nov. 1-Dec. 1.
Montgomery	Nov. 1-Dec. 20.
Prince George	Nov. 9-Dec. 25.
St. Mary	Nov. 1-Jan. 15.
Somerset	Nov. 15-Jan. 1.
Talbot	Nov. 2-Dec. 31.
Squirrel, Sept. 1-Dec. 1 (except as follows):	
Allegany	Sept. 1-Jan. 1.
Anne Arundel	Sept. 1-Dec. 23.
Baltimore	Sept. 15-Nov. 2.
Caroline	Sept. 1-Jan. 15.
Cecil	Sept. 1-Dec. 25.
Frederick	Sept. 1-Nov. 15.
Kent	Sept. 1-Nov. 1.
Montgomery	Aug. 1-Dec. 15.
Washington	Sept. 1-Jan. 2.
Wicomico	Sept. 1-Feb. 15.
Garrett, Prince George	Unprotected.
Quail (partridge):	
Baltimore City (sale), Charles, Frederick, Kent, St. Mary.	Nov. 1-Dec. 24.
Allegany, Dorchestor	Nov. 1-Jan. 1.
Anne Arundel, Queen Anne.	Nov. 15-Dec. 24.
Baltimore	Nov. 10-Dec. 25.
Calvert	Nov. 5-Dec. 24.
Caroline, Somerset, Wicomico, Worcester.	Nov. 15-Jan. 15.
Carroll, Howard	Nov. 10-Dec. 24.

[a] It is unlawful to hunt on election day in Baltimore, Cecil, Frederick, and Harford counties; on Sundays in Baltimore, Prince George, and Washington counties, and on the Patuxent River; when snow is on the ground, in Baltimore, Cecil, Dorchester, Prince George, Somerset, and Worcester counties; from October 10 to November 1 in Frederick County; and at night in any county.

MARYLAND—Continued.

Open Seasons for Game under County Laws—Continued.

Kinds of game.	Open seasons.
Quail (partridge)—Continued.	
Cecil	Oct. 25-Dec. 24.
Garrett, Harford, Washington.	Nov. 1-Dec. 1.
Montgomery	Nov. 1-Dec. 20.
Prince George	Nov. 9-Dec. 25.
Talbot	Nov. 2-Dec. 31.
Ruffed grouse (pheasant):	
Allegany	Nov. 1-Jan. 1.
Anne Arundel	Nov. 15-Dec. 24.
Baltimore	Nov. 10-Dec. 25.
Baltimore City (sale)	Oct. 1-Dec. 24.
Calvert, Caroline, Charles, Frederick, Talbot.	Nov. 1-Dec. 24.
Carroll, Howard, Queen Anne, St. Mary.	Nov. 10-Dec. 24.
Cecil	Sept. 1-Feb. 1.
Dorchester, Wicomico, Worcester.	Nov. 10-Feb. 1.
Garrett, Harford	Nov. 1-Dec. 1.
Kent	No open season.
Montgomery	Sept. 1-Jan. 1.
Prince George	Nov. 9-Dec. 25.
Washington	Nov. 1-Jan. 2.
Wild turkey:	
Allegany	Nov. 1-Jan. 1.
Baltimore, Baltimore City (sale), Calvert, Caroline, Charles, Prince George, Talbot.	Nov. 1-Dec. 24.
Dorchester, Wicomico, Worcester.	Nov. 10-Feb. 1.
Frederick	Nov. 15-Jan. 15.
Garrett	Nov. 1-Dec. 1.
Howard	Nov. 10-Dec. 24.
Kent	No open season.
Montgomery	Nov. 1-Mar. 1.
Washington	Nov. 1-Jan. 2.
Dove, Aug. 15-Dec. 24 (except as follows):	
Carroll, Frederick, Wicomico.	No open season.
Dorchester	Aug. 1-Jan. 1.
Kent	July 15-Dec. 24.
Somerset	Aug. 10-Jan. 1.
Washington	Aug. 15-Sept. 16.
Woodcock:	
Allegany, Dorchester, Montgomery.	July 1-Jan. 1.
Anne Arundel	June 14-Aug. 15.
Baltimore	Nov. 10-Dec. 25.
Baltimore City (sale), Calvert, Frederick, Howard, Kent.	Nov. 1-Dec. 24.[a]
Caroline	July 4-Jan. 15.
Carroll	July 15-Dec. 24.
Cecil	Oct. 25-Dec. 24.
Charles, St. Mary	July 4-Feb. 24.
Garrett	Oct. 1-Dec. 1.
Harford	July 1-Dec. 1.
Prince George	June 30-Dec. 25.
Queen Anne	July 4-Feb. 1.
Somerset	June 15-Jan. 1.
Talbot	July 4-Jan. 1.
Washington	Nov. 1-Dec. 1.
Wicomico	Sept. 15-Feb. 1.
Worcester	Nov. 15-Jan. 15.
Plover, Aug. 15-May 1 (except as follows):	
Anne Arundel	Mar. 2-Aug. 15.
Carroll	Sept. 1-May 1.
Cecil	Sept. 1-Feb. 1.
Kent	July 15-Dec. 24.
Prince George	Sept. 2-May 1.
Wicomico	Nov. 15-Jan. 15.
Somerset, Worcester	Unprotected.
Snipe, Aug. 15-May 1 (except as follows):	
Anne Arundel	Mar. 2-Aug. 15.
Carroll	Sept. 1-May 1.
Cecil	Mar. 1-Dec. 24.
Kent	Mar. 15-June 1.
Prince George	Sept. 2-May 1.
Somerset	Dec. 1-May 1.
Worcester	Unprotected.
Reedbird, Sept. 1-Nov. 1 (except as follows):	
Cecil	Sept. 1-Feb. 1.
Harford	Sept. 1-Dec. 1.
Patuxent River	Sept. 2-Jan. 1.
Somerset	Unprotected.
Rail (ortolan), Sept. 1-Nov. 1 (except as follows):	
Caroline	Sept. 15-Jan. 15.
Cecil	Sept. 1-Feb. 1.
Harford	Sept. 1-Dec. 1.
Talbot	Sept. 10-Jan. 1.
Patapsco and Potomac rivers in Anne Arundel and Prince George counties.	Sept. 5-Nov. 1.
Patuxent River	Sept. 2-Jan. 1.
Somerset	Unprotected.
Duck, (except wood duck), goose, brant, swan, and other wild fowl, Nov. 1-Apr. 10 (except as follows):	
Anne Arundel, on Magothy, Rhode, Severn, and West rivers.[b]	Oct. 1-May 1.[c]
Caroline (duck)[b]	Sept. 15-Apr. 1.
Cecil, on Bohemia, Elk, and Sassafras rivers (except Plum Point to Locust Point).[b]	Nov. 1-Apr. 1.[c]
Charles (nonresidents)	No open season.
Kent,[c] Queen Anne	Nov. 1-Apr. 25.
Patuxent River (duck and goose).	Sept. 2-Apr. 15.
Somerset (duck)	Oct. 1-Apr. 1.
Somerset (goose)	Nov. 1-Apr. 1.
Susquehanna Flats	Nov. 1-Apr. 1.[c]
Talbot, on Great Choptank River.[b]	Oct. 10-May 1.
Allegany (wild fowl) Somerset (brant and swan).	Unprotected.
Wood (summer) duck, Nov. 1-Apr. 10 (except as follows:)	
Charles (acorn duck)	Oct. 1-Apr. 10.
Dorchester	Aug. 1-Jan. 1.
Somerset	Sept. 1-Jan. 1.
Talbot, Wicomico	Sept. 10-Jan. 1.
Worcester	Sept. 1-Mar. 1.

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[a] Also the month of July, except in Kent County.

[b] Otherwise as in state law, which makes open season for all wild fowl Nov. 1-Apr. 10.

[c] Wild-fowl shooting is permitted only on the following days: Anne Arundel: Magothy River, Tuesdays, Thursdays, and Saturdays; Rhode and West rivers, Mondays, Wednesdays, and Fridays; Severn River, Mondays, Wednesdays, and Saturdays. Cecil: Bohemia, Elk, and Sassafras rivers, Mondays, Wednesdays, Fridays, and Saturdays. Kent: Chester River above a line drawn from Cliff City to Spaniard Point, Mondays, Fridays, and Saturdays. Susquehanna Flats: Mondays, Wednesdays, and Fridays in November and December, and Saturdays also during rest of season.

NORTH CAROLINA.

Open Seasons for Game under County Laws.

Kinds of game.	Open seasons.
Deer,[a] Oct. 1-Feb. 1 (except as follows):	
Ashe, Chatham, Davidson, Forsyth, Guilford, Lee, Montgomery, Moore, Randolph,[b] Rockingham, Stanly, Stokes, Surry, Watauga, Wilkes, Yadkin	Nov. 1, 1910.
Beaufort, Northampton	Aug. 15-Feb. 1.
Bladen,[c] Yancey	Nov. 1-Dec. 1.
Brunswick, Craven, Pamlico	Sept. 1-Feb. 1.
Buncombe,[f] Robeson	Nov. 1-Jan. 1.
Burke, Cleveland, Columbus[d]	Oct. 1-Jan. 1.
Carteret, Jones	Aug. 1-Feb. 1.
Caswell	Feb. 23, 1911.
Cherokee	Feb. 28,1917.
Cumberland, Greene	Mar. 5, 1912.
Bertie, New Hanover, Warren	Sept. 1-Jan. 1.
Currituck[e]	Sept. 20-Mar. 1.
Dare	Nov. 15-Jan. 1.
Granville, Person	Sept. 1-Jan. 15.
Halifax	Sept. 15-Feb. 1.
Harnett	Nov. 1, 1914.
Hertford	Oct. 1.-Feb. 1.
McDowell	Feb. 4, 1917.
Madison	Dec. 1-Jan. 1.
Mitchell[f]	Oct. 15-Nov. 1.
Nash	Sept. 1-Nov. 1.
Onslow[g]	No open season.
Richmond,[l] Scotland	Nov. 15-Dec. 15.
Transylvania, Haywood, Henderson, Jackson	Nov. 1-Dec. 15.[f]
Tyrrell[h] [f]	Oct. 15-Feb. 1.
Wake	Nov. 1-Mar. 1.
Camden, Chowan, Duplin, Edgecombe, Gates, Hyde, Johnson, Lenoir, Martin, Pasquotank, Perquimans, Pitt, Washington, Wayne, Wilson	Unprotected.
Squirrel:[b]	
Beaufort.Cleveland, Gates, Perquimans, Pitt, Buncombe, Edgecombe, Nash, Wayne	Oct. 1-Mar. 1.
Bertie, Bladen,[p] (Elizabethtown and Central townships) Dare, Mecklenburg, Sampson	Nov. 1-Mar. 1.
Caldwell[i]	Mar. 3, 1912.
Chowan	Sept. 15-Mar. 15.
Currituck, Pender	Oct. 1-Apr. 1.
Franklin, Warren	Sept. 1-Mar. 1.
Guilford, Greene	Oct. 1-Feb. 1.
Squirrel—Continued.	
Hertford	Nov. 15-Mar. 1.
Lenoir	Sept. 15-Mar. 1.
Madison	Dec. 1-Jan. 1.
Mitchell	Oct. 1-Feb. 15.
Montgomery, Transylvania	Sept. 1-Apr. 1.
Opossum:[b]	
Alamance, Caswell, Chatham, Durham, Franklin, Graham, Greene, Guilford, Halifax, Lee, Mecklenburg, Moore, Orange, Pamlico, Wake, Warren	Oct. 1-Feb. 1.
Clay	Nov. 1-Apr. 1.
Harnett, Lincoln	Oct. 1-Jan. 1.
McDowell	Oct. 15-Mar. 1.
Mitchell	Oct. 1-Feb. 15.
Yadkin	Nov. 1-Feb. 1.
Quail or partridge, Nov. 1-Mar. 1, except as follows:	
Alexander	Feb. 16, 1911.
Alamance, Buncombe	Nov. 15-Feb. 1.
Anson	Nov. 20-Jan. 20.
Burke	Dec. 1-Feb. 15.
Cabarrus	Dec. 1, 1910.
Caldwell	Mar. 3, 1912.
Catawba, Cherokee, Edgecombe, Nash, Davidson, Duplin, Franklin, Halifax, Guilford, Macon, Montgomery, Randolph,[b] [j] Swain, Vance,[m] Wilson	Nov. 15-Mar. 1.
Camden, Clay, Currituck, Iredell, Pasquotank, Perquimans, Rowan, Sampson,[o] Harnett, Warren	Dec. 1-Mar. 1.
Chatham	Nov. 20-Feb. 15.
Cleveland, Lincoln,[n] McDowell, Orange, Polk, Rutherford, Stanly, Stokes, Surry, Yadkin	Dec. 1-Feb. 1.
Columbus	Nov. 1-Apr. 1.
Dare, Tyrrell	Oct. 15-Mar. 1.
Davie	Dec. 15-Feb. 1.
Durham, Madison	Nov. 15-Feb. 1.
Forsyth	Nov. 20-Jan. 1.
Gaston[k]	Nov. 25-Jan. 15.
Granville	Nov. 1-Feb. 1.
Greene	Nov. 20-Feb. 1.
Henderson	Nov. 15-Apr. 1.
Hyde	Oct. 15-Mar. 20.
Mecklenburg	Mar. 5, 1911.
Mitchell	Oct. 1-Feb. 15.
Northampton	Nov. 1-Feb. 15.

[a] Deer raised in private preserves may be killed, sold, or used at any time.

[b] All hunting is prohibited in part of Columbia Township, Randolph County, Jan. 15-Nov. 15, and in another part hunting by landowners and tenants is prohibited Mar. 1-Nov. 15.

[c] In Carver Creek, White Creek, French Creek, Cyprus Creek, Turnbull and Colby townships, no open season.

[d] Within half mile of Lake Waccamaw.

[e] On north side of Poplar Branch Township.

[f] Deer without horns protected all the year.

[g] In New River or within 100 yards thereof.

[h] In part of region between Alligator River and county line, and in South Fork Township, Aug. 1-Feb. 15.

[i] Except by permission of landowner Nov. 20-Jan. 1.

[j] In Franklinsville Township, Nov. 15-Jan. 15.

[k] Close season extends to last Thursday in November.

[l] All hunting prohibited in Steele Township, Feb. 15-Nov. 20.

[m] All hunting prohibited, March 1-Nov. 15.

[n] Protected in North Brook Township until Mar. 7, 1910.

[o] Except Taylors Bridge Township, Nov. 1-Mar. 1.

[p] White Oak Township, Oct. 1-Mar. 1.

NORTH CAROLINA—Continued.

Open Seasons for Game under County Laws—Continued.

Kinds of game.	Open seasons.
Quail or partridge, etc.—Con.	
Richmond,[a] Scotland	Nov. 20-Mar. 1.
Union	Dec. 15-Jan. 15.
Watauga[b]	Sept. 1-Mar. 1.
Graham, Onslow	Unprotected.
Pheasant[c]:	
Ashe, Chatham, Davidson, Forsyth, Guilford, Lee, Montgomery, Moore, Randolph,[c] Richmond, Rockingham, Stanly, Surry, Watauga, Wilkes, Yadkin	Nov. 1, 1910.
Anson	Jan. 29, 1912.
Buncombe	Nov. 15, 1913.
Burke	Dec. 1-Feb. 15.
Cherokee	Feb. 28, 1912.
Edgecombe	Nov. 15-Mar. 1.
Clay	Dec. 1-Mar. 1.
Granville, Macon	Nov. 1-Mar. 1.
Henderson	Nov. 1-Apr. 1.
McDowell	Jan. 1, 1912.
Madison	Nov. 15-Feb. 1.
Mitchell	Oct. 1-Feb. 15.
Orange, Polk, Rowan, Stokes	Dec. 1-Feb. 1.
Randolph	Nov. 15-Dec. 15.
Rutherford (English, Mongolian).	Mar. 8, 1913.
Scotland	Nov. 20-Mar. 1.
Swain	Nov. 20-Jan. 1.
Transylvania (English, Mongolian, Nov. 1, 1910).	Nov. 1-Mar. 1.
Watauga	Jan. 1, 1911.
Wild turkey, Nov. 1-Mar. 1 (except as follows):	
Anson	Nov. 20-Jan. 20.
Alamance, Madison	Nov. 15-Feb. 1.
Bladen,[e] Clay, Randolph,[f] Rowan, Stokes, Orange, Polk, Stanly.	Dec. 1-Feb. 1.
Buncombe	Nov. 15, 1913.
Burke	Dec. 1-Feb. 15.
Cabarrus, Warren	Dec. 1-Mar. 1.
Cherokee, Davidson, Guilford, Macon, Wilson, Vance.	Nov. 15-Mar. 1.
Columbus	Nov. 1-Apr. 1.
Davie	No open season.
Edgecombe	Nov. 15-Feb. 15.
Henderson	Nov. 15-Apr. 1.
Mitchell	Oct. 1-Feb. 15.
Northampton	Nov. 1-Feb. 1.
Pender	Oct. 1-Feb. 1.
Richmond, Scotland	Nov. 20-Mar. 1.
Union	Dec. 15-Jan. 15.
Carteret, Dare, Graham, Onslow, Swain, Tyrrell.	Unprotected.
Dove, lark, robin, Nov. 1-Mar. 1 [f] (except as follows):	
Alamance	Nov. 15-Feb. 1.
Anson (dove)	Nov. 20-Jan. 20.
Buncombe (dove) Mecklenburg.	Nov. 15-Feb. 1.
Burke	Dec. 1-Feb. 15.
Cabarrus, Cherokee, Guilford, Macon (dove), Edgecombe.[g]	Nov. 15-Mar. 1.
Columbus (dove)	Nov. 1-Apr. 1.
Dove, lark, robin, Nov. 1-Mar. 1 (except as follows)—Con.	
Davidson	Oct. 15-Apr. 1.
Davie, Rowan, Warren (dove).	Dec. 1-Mar. 1.
Halifax (dove)	Jan. 1-Apr. 1.
Henderson	Nov. 15-Apr. 1.
Hyde	Nov. 1-Mar. 15.
Madison (except dove, Nov. 15-Feb. 1).	Dec. 1-Jan. 1.
Mitchell	Oct. 1-Feb. 15.
Northampton (except dove, Nov. 1-Feb. 15).	Nov. 1-Feb. 1.
Richmond, Scotland (dove).	Nov. 20-Mar. 1.
Stokes, Stanly, Orange	Dec. 1-Feb. 1.
Union	Dec. 15-Jan. 15.
Vance	Nov. 15-Mar. 15.
Carteret, Duplin, Graham, Moore, Onslow, Swain, Wilson.	Unprotected.
Woodcock:	
Anson[d]	Nov. 20-Jan. 20.
Brunswick, New Hanover, Pender.	Sept. 1-Jan. 1.
Cherokee, Granville, Randolph.[f]	Nov. 1-Mar. 1.
Craven, Jones	Nov. 1-Feb. 1.
Cabarrus	Dec. 1, 1910.
Edgecombe	Nov. 15-Mar. 1.
Henderson	No open season.
Madison	Dec. 1-Jan. 1.
Mitchell	Oct. 1-Feb. 15.
Rowan, Stokes, Orange	Dec. 1-Feb. 1.
Warren	Dec. 1-Mar. 1.
Snipe:[f]	
Anson[d]	Nov. 20-Jan. 20.
Brunswick, New Hanover.	Sept. 1-Mar. 1.
Cherokee, Edgecombe	Nov. 15-Mar. 1.
Granville	Nov. 1-Mar. 1.
Halifax, Warren	Feb. 1-May 1.
Madison	Dec. 1-Jan. 1.
Mitchell	Oct. 1-Feb. 15.
Marsh hen, curlew, and other shore birds:[f]	
Anson[d]	Nov. 20-Jan. 20.
Carteret	Aug. 15-Apr. 1.
Cherokee, Edgecombe.	Nov. 15-Mar. 1.
Granville	Nov. 1-Mar. 1.
Henderson	No open season.
Madison	Dec. 1-Jan. 1.
Pender, New Hanover, Brunswick.	Aug. 1-Feb. 1..
Stokes, Orange	Dec. 1-Feb. 1.
Wildfowl:[f]	
Anson[d]	Nov. 20-Jan. 20.
Beaufort (summer duck)	Sept. 15-Feb. 1.
Bladen[e]	Dec. 1-Feb. 1.
Brunswick, New Hanover.	Sept. 1-Mar. 1.[h]
Carteret[i]	Oct. 1-Apr. 1.
Cherokee, Edgecombe	Nov. 15-Mar. 1.
Craven, Granville, Jones, Wake.	Nov. 1-Mar. 1.
Currituck[j]	Nov. 10-Apr. 1.
Dare[k]	Nov. 10-Mar. 10.
Guilford (except wood duck, no open season).	Oct. 1-Mar. 1.
Henderson	No open season.
Madison	Dec. 1-Jan. 1.

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[a] All hunting prohibited in Steele Township, Feb. 15-Nov. 20.

[b] In Cove Creek Township no open season.

[c] Includes native pheasant or grouse and in some cases imported pheasants.

[d] In Lanesboro Township only.

[e] In Colly, Cypress Creek, French Creek, and Turnbull townships.

[f] All hunting is prohibited in part of Columbia Township, Randolph County, Jan. 15-Nov. 15, and in another part hunting by landowners and tenants is prohibited Mar. 1-Nov. 15.

[g] Except dove, July 15-Jan. 1.

[h] Ducks only.

[i] Sundays and Mondays are closed.

[j] Wednesdays, Saturdays, and Sundays are closed to all hunting. Ring shooting permitted only Feb. 15-Apr. 1.

[k] Wednesdays and Saturdays are closed.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 377.

HARMFULNESS OF HEADACHE MIXTURES.

BY

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AND

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1909.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., August 4, 1909.

SIR: Bulletin 126 of the Bureau of Chemistry reports the results of an investigation with regard to the harmful effects of acetanilid, antipyrin, and phenacetin. The data are there presented in detail and in a somewhat technical manner; hence it seems advisable, in view of the wide use of these agents in remedies sold without a physician's prescription, especially in headache mixtures, that the general public should be informed as to the nature of these drugs, their tendency to form habits, and their injurious effects, particularly their depressing action on the heart.

The beneficial effects of that provision of the food and drugs act which requires that the presence of certain powerful or dangerous ingredients of medicinal preparations shall be declared on the label are only fully obtained when the consumer is aware of the character of such ingredients and the ill effects which may be expected to follow their injudicious use. This brief résumé of the investigation is therefore presented in popular form as a matter of great importance to the general public, and its publication as a Farmers' Bulletin is recommended in order to insure the widest publicity.

Respectfully,

H. W. WILEY,
Chief, Bureau of Chemistry.

HON. JAMES WILSON,
Secretary of Agriculture.

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HARMFULNESS OF HEADACHE MIXTURES.

CHARACTER AND USE OF ACETANILID, ANTIPYRIN, AND PHENACETIN.

Acetanilid, antipyrin, and phenacetin are very commonly used in the preparation of mixtures intended for the relief of headache and other minor aches and pains. Thus there will often be seen upon the label of a headache powder, beneath the name of the preparation, a statement like the following: "Acetanilid, 240 grains per ounce." This means that each ounce of the preparation contains 240 grains of acetanilid, or, inasmuch as there are 480 grains in an ounce, that each powder is one-half acetanilid. Or the following may appear on the label: "Phenacetin, 120 grains per ounce," which means that each powder is one-fourth phenacetin. These drugs are white powders with comparatively little taste, and are often described together, as they are similar in many respects and have somewhat the same effects on the human body. They are known as coal-tar products for the reason that they are obtained indirectly from coal tar and possess the characteristics of the derivatives of that substance.

INTRODUCTION OF ACETANILID, ANTIPYRIN, AND PHENACETIN AS MEDICINES.

Acetanilid was introduced as a medicine in 1886. It had been known for many years before, but had possessed only a chemical and commercial interest. In the summer of 1886 a physician in one of the hospitals in Strassburg, Germany, noticed that the administration of acetanilid to a patient suffering from fever caused his temperature to fall. On giving the drug to other patients and finding that the fever was reduced in these cases also, he reported the results of his observations to other physicians, and this was the beginning of the use of acetanilid as a drug.

Antipyrin was introduced as a medicine in 1884. Its production was the result of chemical research, and for many years it was made according to a patented process.

The discovery of phenacetin in 1887 was also brought about by chemical investigation. It was the result of laboratory research, carried on with the object of discovering, if possible, some agent of the coal-tar class which would reduce fever, and, while possessing the desirable characteristics of acetanilid, be free from its undesirable effects. The object in view was only partially attained, however, for phenacetin possesses many of the harmful characteristics of acetanilid.

UNFAVORABLE SYMPTOMS PRODUCED.

The unfavorable symptoms produced by these drugs affect principally the heart and circulation and through them other parts of the body, and are generally observed as the result of their ill-advised use in the form of "patent" medicines for the relief of headache and other forms of pain. The symptom which occurs most frequently in poisoning by these drugs is blueness of the skin. If the dose taken has not been very large, the discoloration may be very slight and may affect only a small portion of the body. Thus in some persons who habitually use headache medicines containing these drugs, all that may be noted is an occasional blueness of the lips and mouth and possibly of the nails and finger tips. If, however, the doses are larger, or are taken more frequently, the blueness may affect the skin of the whole body. This peculiar effect was noticed by the physicians who first administered these remedies, when they were given in much larger doses than now, but little attention was paid to it, as it appeared to be a passing effect only. Since then, however, it has been learned that the bluing of the skin is not a harmless manifestation, but is due to destructive changes in the blood which are the direct result of the use of the drug, and that it is accompanied by impoverishment of the blood. Hence those who take these remedies habitually often suffer from "anemia," or thin blood, and the symptoms which usually accompany this condition—pallor, shortness of breath, palpitation of the heart, muscular weakness, disinclination to make any exertion, etc. The injudicious use of these remedies also has a harmful effect upon the heart, thus tending to exaggerate the symptoms above mentioned. In addition it may give rise to other ill effects which arise from weakness of the circulation.

OBJECTS FOR WHICH THESE DRUGS ARE USED.

As already stated, acetanilid, antipyrin, and phenacetin were at first used almost exclusively for the reduction of fever, but as time went on they were employed less and less for this purpose, because of their weakening effects, particularly upon the heart and circulation. They gradually came to be used more and more for the relief of pain, however, and to-day this constitutes their chief field of usefulness. During the time when they were used principally for reducing fever they were employed under the supervision of the physician and were administered with medical skill and judgment, but as their power to relieve pain has become better known they have been used more and more by the people generally, without medical supervision, for the relief of headache and other minor ills. At present they are extensively advertised and sold to be used in this way, largely in the form of so-called patent medicines. The injudicious use of these drugs has produced bad effects in many instances. Furthermore, the number of reported cases of poisoning by at least one of them has increased notably during the last few years.

REASONS FOR THE INVESTIGATION.

Since the passage of the food and drugs act, June 30, 1906, the attention of the Department of Agriculture has been directed to this subject, particularly in connection with the proper labeling of drug products, and an attempt has been made to obtain full and reliable information with regard to the harmful effects of acetanilid, antipyrin, and phenacetin. While the majority of manufacturers have shown a disposition to comply with the law by naming upon the label the drugs enumerated in section 8 of the food and drugs act, and their derivatives and preparations, investigation shows that many medicines containing these or other dangerous agents bear statements which are not in harmony with the facts. The misrepresentation often takes the form of assertions to the effect that the remedy is harmless or that it contains no poisonous or harmful ingredients. Again, the public is given to understand in many cases that the medicine can be taken freely and safely until the desired effect is obtained. Some of the manufacturers of acetanilid preparations go even further and assert that the medicine, in addition to being an efficient remedy, acts as food or nourishment for the upbuilding of some particular part of the body; that it is, in short, a "nerve food" or a "brain food." Claims of this character are, however, without foundation, because so far as known there is no substance which acts as a food for one part of the body without acting as a food for the rest of the body as well. Moreover, as already stated, the frequently repeated or continued use of acetanilid tends to impair the nutrition of the body.

The purpose of this inquiry was not to depreciate in any way the value of these substances as medicines, but rather to furnish information to the public which would enable them to understand that, in the absence of reliable medical advice, these remedies should be employed with caution.

METHOD OF INVESTIGATION.

The investigation was conducted along two lines: (1) An inquiry was addressed to physicians in the United States with regard to their personal experience with these drugs in the practice of their profession. Nearly a thousand circular letters, each containing 18 questions, were sent out, and 400 replies were received. (2) A study was made of the cases of poisoning recorded in medical literature. Physicians often publish in medical periodicals descriptions of cases of poisoning observed by them in the course of practice, on account of the interest they possess for practitioners generally. Such cases are said to have been "reported" or "recorded."

SUMMARY OF RESULTS OF INVESTIGATION.

The results obtained in this investigation are summarized in the following table. Section A contains information with regard to a number of instances quoted in medical literature in which poisoning, death, or a drug habit has been known to result from the use of acetanilid, antipyrin, or phenacetin. The information set forth in Section B was furnished by the 400 physicians who replied to the circular letter issued by the Department. Nine hundred and twenty-five of these letters were sent out and, as already stated, 400 replies were received. Granting that the 525 physicians who did not reply had no cases to report, the question may profitably be asked, If 925 physicians have observed 814 cases of poisoning by these drugs, 29 deaths attributed to their use, and 136 instances of habitual use, how many such cases have in all probability been observed by the 125,000 physicians scattered throughout the United States? Section C gives the total of the cases recorded in medical literature added to those reported by the physicians.

Cases in which deleterious or fatal effects have been produced by acetanilid, antipyrin, and phenacetin.

A. CASES RECORDED IN MEDICAL LITERATURE, 1884–1907.

Substance.	Poisoning.	Deaths.	Habitual use.
Acetanilid	297	13	32
Antipyrin	488	10	....
Phenacetin	70	3	1
Total	855	26	33

B. CASES REPORTED BY 400 PHYSICIANS, 1908.

Acetanilid	614	17	112
Antipyrin	105	5	7
Phenacetin	95	7	17
Total	814	29	136

C. TOTAL OF COLLATED CASES (A AND B).

Acetanilid	911	30	144
Antipyrin	593	15	7
Phenacetin	165	10	18
General total	1,669	55	169

INFORMATION FURNISHED BY PHYSICIANS.

CHANGE IN ATTITUDE OF PHYSICIANS.

The replies to the circular letter indicate that while the use of these agents among the people generally has been increasing during recent years, their use by physicians has been decreasing. Sixty-six per cent of the physicians stated that they use acetanilid less frequently than formerly. Nearly 66 per cent made the same statement with regard to antipyrin, and 51.2 per cent with regard to phenacetin. The reason given related in nearly every instance to the poisonous properties of these drugs, particularly their depressing effect upon the heart. The fact that they are poisons in the true sense of the word is generally recognized by physicians, but it is doubtful whether the people generally realize that they possess any harmful properties whatever. Certainly there is nothing to indicate an appreciation of this fact, if one can judge from the extent to which these drugs and the preparations containing them are used without the advice of a physician.

OPINIONS AND PRACTICE OF PHYSICIANS.

From the replies made to the more detailed questions sent to the physicians the following information was obtained:

Extent of use of these drugs (acetanilid, antipyrin, phenacetin) by physicians.—Thirty per cent of the physicians stated that they use acetanilid frequently or moderately, 28 per cent do not use it at all, and 25 per cent use it but rarely. Thirty-six per cent use phenacetin frequently or moderately, 23 per cent do not use it, and 21 per cent use it but rarely. Only 5 per cent use antipyrin frequently or moderately, 52 per cent do not use it, and 25 per cent use it but rarely.

Dose.—The replies to this question indicate that the doses prescribed to-day are much smaller than those formerly employed. The therapeutic committee of the British Medical Association made a report in 1894[a] on this subject, and concluded that the ill effects which had been ascribed to these remedies were very largely the direct result of injudicious and excessive dosage. In harmony with this conclusion they suggested that these drugs should be used with greater caution in the future. Since that time the doses employed have been smaller than before, and it has been noted that coincidentally with this change the number of accidents resulting from taking these remedies has fallen off to a remarkable extent. A point of interest in connection with the subject of dosage and frequency of administration was brought out in a recent trial. The evidence showed that the directions for use accompanying many of these acetanilid preparations are not sufficiently definite to safeguard the patient against taking the medicine too frequently, and, in fact, that many of them advise a repetition of the dose until the desired result is obtained. An examination of a number of prescriptions for adults on file in various pharmacies in Washington, D. C., brought into court as evidence, supplied the following information on these points: (1) The average dose of acetanilid prescribed was 2.43 grains, and of phenacetin 1.92 grains; (2) the average interval between doses was 3.03 hours.

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[a] See British Medical Journal, 1894, vol. 1, page 85.

Relative harmfulness of these drugs.—Phenacetin was regarded as the least dangerous by 67 per cent of the physicians, acetanilid by 16 per cent, and antipyrin by 5 per cent. About 10 per cent considered one to be about as weakening to the system as the other.

Number of cases of poisoning by these drugs.—The number of cases of poisoning observed by the physicians who replied to this question was as follows: Acetanilid, 614 cases, 17 of which were fatal; antipyrin, 105 cases, 5 of which were fatal; and phenacetin, 95 cases, 7 of which were fatal.

Form in which drug was taken.—The replies showed that in 77, or 12 per cent, of the cases of poisoning, "patent" medicines containing acetanilid were taken and that in 44 per cent of the cases of habitual use of acetanilid, "patent" medicines containing this drug were employed.

Ailment for which medicine was taken.—In a large majority of cases (446 out of 720) the remedy was taken for headache. This was particularly true of acetanilid. This medicine was reported to have been taken for the relief of pain in 65 cases and for fever in 160.

It is not generally known that the application of acetanilid to the skin, either alone or in combination with some other powder like boric acid, may cause symptoms of poisoning. Nevertheless this is true. In 2.3 per cent of the cases of poisoning reported by physicians the ill effects followed the local use of this agent in the treatment of ulcers, burns, chafing, or some other form of skin trouble. A portion of the drug placed upon the diseased surface is absorbed through the skin and taken up in the body fluids and may produce unfavorable symptoms affecting the whole body. A number of cases of this kind have been recorded in medical journals, and brief abstracts of six of them may be found on pages 10 and 11.

Habitual use.—It has long been known that acetanilid, antipyrin, and phenacetin are habit-forming drugs, particularly acetanilid. The habit is usually acquired through the use of the remedy without the supervision of a physician for the relief of minor aches and pains, especially headache. Troubles of this kind are peculiarly likely to return again and again, and the remedy has but a temporary effect; hence the dose must be repeated, and in time the patient may become dependent upon the drug. Furthermore, the ache or pain for which the medicine was first taken is often worse than ever after the effects of the remedy have passed away, because of the weakened condition of the system which may result from the use of these agents, and hence there is additional call for the remedy. Thus a habit may be established—more drug, impaired bodily health, lessened resistance, more pain, more drug.

In reply to the inquiry by the Department, 112 instances of the acetanilid habit were reported, 7 of the antipyrin habit, and 17 of the phenacetin habit. It should be remembered, however, that neither these cases nor those which are recorded in medical literature give an adequate indication of the extent to which these drugs are used habitually, inasmuch as only those cases have been reported in which the ill effects were so marked as to call for the services of a physician.

The principal symptoms which were reported by the physicians to have resulted from the habitual use of these agents were blueness of the skin, heart weakness, impoverishment of the blood, shortness of breath on exertion, nervous depression, sleeplessness, and loss of memory. In not a few cases the patients were reduced to a condition of invalidism.

Protracted ill effects.—Lasting ill effects were observed from the use of acetanilid in 38 cases, antipyrin in 2 cases, and phenacetin in 5 cases. The chronic symptoms most frequently noted were impoverishment of the blood, general weakness, nervousness, and weak and irregular heart action.

CASES OF POISONING RECORDED IN MEDICAL LITERATURE.

ACETANILID.

Number of cases recorded and their distribution.—From the time of the introduction of acetanilid as a medicine in 1886 until the end of the year 1907, about 300 cases of poisoning by this drug were recorded in medical publications. The exact number of cases could not be accurately determined because some of the physicians did not state definitely the exact number of cases they had seen. The cases were reported by 177 physicians, the number recorded for each year being as follows:

Cases of acetanilid poisoning recorded, 1886–1907.

Year.	Number of cases.	Ratio to total cases in entire period.	Year.	Number of cases.	Ratio to total cases in entire period.
		Per cent.			*Per cent.*
1886	20	6.7	1898	3	1.0
1887	94	31.5	1899	2	.6
1888	21	7.0	1900	2	.6
1889	23	7.7	1901	6	2.0
1890	27	9.0	1902	2	.6
1891	9	3.0	1903	4	1.3
1892	5	1.6	1904	1	.3
1893	5	1.6	1905	9	3.0
1894	7	2.3	1906	19	6.3
1895	6	2.0	1907	8	2.6
1896	20	6.7			
1897	4	1.3	Total	297	....

Of the total number of cases recorded, 114, or more than one-third, were reported during the year and a half following the introduction of acetanilid as a medicine, and 185, or more than one-half, were reported during the first four and a half years of its history. The occurrence of so many cases during this period was undoubtedly due in part to the fact that at this time the poisonous properties of acetanilid were not understood and its possibilities for harm were not known or appreciated. After the drug had been more thoroughly studied and its harmful effects in many cases had been brought to the attention of physicians, partly through personal experience and partly through reports published in the medical press, it was used with greater caution, especially when the patient showed signs of weakness. As a result the cases of poisoning decreased rapidly, and during the thirteen years following 1891 the number averaged less than 6 annually. Since the year 1904, however, there has been a notable increase in the number of cases reported, as well as in the number of deaths. This can be adequately explained only by the fact that during recent years the control of acetanilid as a medicine has rapidly passed from the hands of physicians to those of the people, owing largely to the extensive advertising of so-called patent medicines; and the increase in the number of cases reported and in the number of deaths is undoubtedly mainly due to the ill-advised use of remedies containing acetanilid by the general public for the relief of headache and other minor ills.

Fatalities.—Of the 297 cases of poisoning recorded, 13, or 4.4 per cent, terminated fatally. It is interesting to note that although 185, or 62.3 per cent, of all the cases that were recorded fell during the first four and one-half years of the history of acetanilid as a medicine, the number of deaths from acetanilid poisoning which occurred during this time was only 3, making the percentage of fatalities 1.6; whereas during the last three years, since the drug has been used more or less indiscriminately by the public, the percentage of fatalities recorded has been 16.6.

Discussion of symptoms and effects.—The fact that acetanilid when applied to the skin can give rise to symptoms of poisoning has already been mentioned. In 26, or 8.7 per cent, of the cases of poisoning by acetanilid recorded in medical literature the symptoms resulted from external application. These cases are of especial interest, as they afford a good illustration of the poisonous nature of the drug. In one of these cases the poisoning resulted fatally.[a] The following abstract taken from a report by Gartman and Ball in 1897 [b] gives an illustration of the symptoms in this class of cases:

> Child, 3½ years old. A scalded area of skin was dressed with 3 ounces of a 10 per cent ointment of acetanilid. Two days later 3 ounces were again applied, and the child began to turn blue. The color deepened until the skin and visible mucous membranes were of a blackish-blue color, and symptoms of collapse appeared. The ointment was discontinued and the symptoms gradually disappeared.

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[a] "Poisoning by acetanilid." Article by C. W. Rook in the Journal of the American Medical Association, 1896, vol. 26, p. 239.

[b] "A case of acetanilid poisoning." Article in the Philadelphia Polyclinic, 1897, vol. 6, p. 381.

The symptom which appears most frequently in the recorded cases of poisoning by acetanilid is blueness of the skin, particularly of the finger tips, the nose and ears, and the lips and lining membrane of the mouth. Among the other symptoms observed are general weakness, dizziness, faintness, lividity of the face, a pinched and anxious expression, shortness of breath, great restlessness, sweating, coldness of the extremities, rapid and weak pulse, and, in severe cases, stupor and loss of consciousness. The habitual use of acetanilid is specifically mentioned in 32, or 10.8 per cent, of the recorded cases of poisoning.

The use of so-called patent medicines containing acetanilid is not mentioned in the reports of cases published during the eight years preceding the year 1905, but in the reports published during 1905 the use of these preparations is indicated in 55 per cent of the cases. In 1906 their use is indicated in 63.1 per cent of the recorded cases, and in 1907 in 87.5 per cent. Accompanying this rapid increase in the use of "patent" medicines containing acetanilid during recent years, which indicates a wider use of acetanilid by the general public, there has been an increase in the total number of cases of poisoning recorded, in the number of fatalities, and in the number of instances of habitual use.

Abstracts of acetanilid cases.—Following are brief abstracts of cases of poisoning by acetanilid taken from the reports published by physicians in medical periodicals. They illustrate the symptoms which are often observed in poisoning by this drug.

(1) Child, 6 weeks old: Frequent application of a powder consisting of equal parts of acetanilid and subgallate of bismuth to an inflamed area on the buttocks was followed by blueness of the skin of the entire body. (2) Boy, 2½ years: Similar powder dusted on a scalded surface caused blueness of lips, ears, and finger tips, extending to the entire skin, and symptoms of depression.—"Two cases of acetanilid poisoning in children from absorption from external wounds," by J. L. Manassee, in International Medical Magazine, New York, 1901, vol. 10, p. 278.

(1) A raw surface was copiously dusted with acetanilid. Next morning the patient was blue, collapsed, and unconscious. (2) Child, four months: Application of a powder consisting of one-half drachm of calomel and two drachms each of bismuth subgallate and acetanilid to the skin was followed by intense blueness of the skin.—"Toxic effects of acetanilid," by F. T. Stewart, in Philadelphia Medical Journal, 1901, vol. 8, p. 379.

Woman, 37: For eleven months she had dressed an ulcer of the leg with acetanilid, and during this time had run down in health and lost 70 pounds. Suffered from blueness of the skin, abdominal pain, general nervousness, shortness of breath, nausea and occasional vomiting, headache, and dizziness. Urine of a dark, amber tint. Examination showed impoverishment of the blood.—"A case of acetanilid poisoning from absorption," by R. M. Goepp, in Journal of the American Medical Association, Chicago, 1906, vol. 47, p. 359.

(1) Man, 38: Habitual use of acetanilid in the form of cephalgin for a year caused progressive loss of flesh and strength, somnolence, blueness of the skin, increasing weak-

ness, irritability of temper, and irregular heart action, the pulse becoming rapid on slight exertion. (2) Woman, 27: Habitual use of about 20 grains of acetanilid daily in the form of headache tablets caused progressive loss of health and strength, with blueness of the skin, shortness of breath, headache, palpitation of the heart, increasing rapidity of the pulse and respiration, especially on exertion, and deterioration in the quality of the blood.—"Chronic acetanilid poisoning; report of two additional cases," by A. Stengel, in Journal of the American Medical Association, Chicago, 1905, vol. 45, p. 243.

A young woman, physically sound, had been taking orangeine powders for several weeks for sleeplessness. Her family noticed that her skin had a bluish tinge, and sent for a physician. He found the skin of face, lips, and extremities blue. She was also faint and chilly. Had taken 6 of the powders within eight hours. Her family promised that she should obtain no more, but three days afterwards she was found dead in bed in the morning. Coroner's verdict: "Death was from the effect of an overdose of orangeine powders administered by her own hand, whether accidentally or otherwise unknown to the jury."—"Poisoning by orangeine," by J. L. Miller, in Journal of the American Medical Association, Chicago, 1905, vol. 44, p. 1989.

(1) Man, 63: Chronic bronchitis and palpitation of the heart for two years. Pulse 160 and weak, becoming irregular upon exertion. Loss of appetite, constipation, blueness of the skin, varying in degree at different times. Had been addicted to the use of acetanilid for a year, taking 40 to 60 grains daily. Last two months he had been running down until he was confined to bed. Dose of acetanilid was reduced to 10 grains daily. He gradually improved and at end of a year was in fairly good health. (2) Man, 32: Suffered from blueness of the skin, coldness of extremities, insomnia, impaired appetite, constipation, nervousness, and anemia. Urine, albuminous. Heart, rapid and feeble. Had been taking acetanilid for eight months, 12 to 40 grains daily, and his health had failed rapidly. The drug was entirely withdrawn and after a month he was in fairly good condition. After abstaining for eight months he again contracted the habit and his health again became impaired.—"A report of three cases of addiction to the coal-tar derivatives," by J. S. Davis, in American Medico-Surgical Bulletin, 1894, vol. 7, p. 1490.

(1) Woman, 34: For six weeks she had suffered from dizziness, shortness of breath, loss of appetite, nausea, and severe headaches. Her physician found her unconscious, skin blue, and in profound collapse. Inquiry showed that she had been taking bromo-seltzer for two weeks in tablespoonful doses for pain. (2) Woman, 32: Use of headache wafers over a period of three weeks caused nausea and vertigo, attacks of fainting, blueness of the skin, loss of memory, and difficulty in concentrating the thoughts. Pulse, rapid, soft, and intermittent; urine scant. Convalescence lasted two months. (3) Woman, 39: Habitual use of headache powders containing 6 grains of acetanilid powder each, caused nausea, general nervousness and debility, blueness, and rapid intermittent pulse. (4) Woman, 69: Case similar to the preceding. (5) Woman, 36: Had been taking bromo-seltzer in tablespoonful doses for headache for two months. Collapsed in the street. Symptoms resembled those in preceding case.—"Acetanilid poisoning," by E. L. Sutherland, in Medical Sentinel, Portland, Oreg., 1906, vol. 14, p. 466.

(1) Man, 40: Habitual use of acetanilid for two years caused gradual loss of health, blueness of the skin, general debility with loss of heart tone, and deterioration in the quality of the blood. (2) Man, 50: Habitual use of acetanilid for two years caused progressive loss of flesh and strength, the weight falling from 140 to 116, frequent vomiting, blueness of the skin, deterioration in the quality of the blood, mental dullness, and general debility amounting to invalidism.—"Chronic poisoning by acetanilid," by D. D. Stewart, in Journal of the American Medical Association, Chicago, 1905, vol. 44, p. 1725.

Woman, 45: Habitual use of acetanilid in the form of Harper's brain food caused general malaise, drowsiness, fatigue on slight exertion, numbness of lower extremities, impaired locomotion, blueness of the skin, puffiness of the skin, tremor, and rapid pulse.—"Chronic acetanilid poisoning from Harper's 'brain food,'" by L. W. Glazebrook, in Journal of the American Medical Association, Chicago, 1907, vol. 49, p. 1673.

Man, 50: Habitual use of acetanilid, 30 to 40 grains daily, for six months caused a loss of 20 pounds in weight, blueness of face and mucous membranes, deterioration in the quality of the blood, and marked general weakness.—"Chronic cyanosis from acetanilid poisoning," by J. N. Hall and H. R. McGraw, in Boston Medical and Surgical Journal, 1903, vol. 149, p. 626.

ANTIPYRIN.

Number of cases recorded and their distribution.—The total number of cases of poisoning by antipyrin recorded in medical literature is approximately 488. They were reported by 299 physicians. Of the 488 cases, 10, or about 2 per cent, are reported to have resulted fatally. The distribution of the recorded cases by years from the time of the introduction of antipyrin as a medicinal agent, in 1884, to the end of the year 1907, is shown in the accompanying table.

Cases of antipyrin poisoning recorded annually.

Year.	Number of cases recorded.	Number of observers.	Year.	Number of cases recorded.	Number of observers.	Year.	Number of cases recorded.	Number of observers.
1884.........	33	19	1893.........	13	10	1902.........	4	4
1885.........	68	28	1894.........	16	16	1903.........	8	8
1886.........	48	18	1895.........	28	17	1904.........	7	6
1887.........	37	27	1896.........	13	13	1905.........	3	3
1888.........	55	41	1897.........	31	20	1906.........	5	5
1889.........	24	18	1898.........	22	11	1907.........	2	2
1890.........	22	8	1899.........	2	2			
1891.........	12	11	1900.........	0	0	Total....	488	299
1892.........	34	11	1901.........	1	1			

These figures indicate either that there has been a considerable falling off in the use of antipyrin during recent years, or that the drug has been employed with greater caution and discrimination, and undoubtedly both of these factors have played an important part in reducing the number of cases of poisoning.

Discussion of symptoms.—A review of the recorded cases of poisoning by antipyrin shows that in a number of instances a single dose of 5 grains or less has produced alarming symptoms in adults, while a dose of 10 or 15 grains has produced serious consequences. In many cases of harmful results the dose appears to have been neither unduly large nor long continued. From this it would appear that some persons are much more easily affected by antipyrin than others; in other words, the same dose may not affect one person unfavorably, but may produce serious symptoms of poisoning in another. This uncertainty of effect has undoubtedly been an important factor in bringing about a more cautious use of antipyrin by physicians. How much more cautiously should it be used, if at all by the people at large, without the supervision of a physician?

Abstracts of antipyrin cases.—The following abstracts of cases illustrate the symptoms which have been observed in cases of poisoning by antipyrin:

A dose of 10 grains of antipyrin in one case caused the appearance of an eruption resembling hives, and in another violent sneezing, swelling of the nose and throat, and shortness of breath.—"Peculiar susceptibility to the effects of antipyrin," by E. Knight, in British Medical Journal, London, 1895, vol. 1, p. 1132.

The use of antipyrin was followed by the appearance of a bright red eruption over the body resembling that of scarlatina.—"Eruption from the use of antipyrin," by Tisné, in Journal de médecine de Paris, 1888, vol. 15, p. 327.

(1) The taking of a teaspoonful of headache powder was followed by general itching, an eruption upon the skin, and marked depression. (2) A dose of 15 grains of antipyrin was followed by an eruption resembling that of measles, and great swelling of the face.—"Two cases of antipyrin rash," by K. Löwy, in Archiv für Dermatologie und Syphilis, Vienna, 1904, vol. 68, p. 167.

(1) Boy, 9: The administration of 10 grains of antipyrin was followed by blueness of the skin and symptoms of collapse. (2) Symptoms of collapse followed the ingestion of two 10-grain doses of the drug. (3) Eruption resembling that of measles appeared after the use of antipyrin.—"Clinical value of antipyretics," by L. J. Brooks, in Medical Times, Philadelphia, 1886–87, vol. 17, p. 794.

Paul Binet reported to the Medical Society of Geneva, September 5, 1888, a case in which a dose of 7.5 grains of antipyrin was followed by swelling of the eyelids, an itching eruption, nausea, dizziness, pain around the heart, and loss of consciousness.—Published in Revue médicale de la Suisse romande, Geneva, 1888, vol. 8, p. 635.

(1) Man, 32: Took 10 grains of antipyrin for headache. Within two minutes he was seized with alarming symptoms—a feeling of suffocation, swelling of the face so that the lids were closed, running of the eyes, and shortness of breath. The tongue was much swollen and the speech thick. There was no eruption. He was at work the next day with a slight swelling of the face. He had previously suffered from a similar attack, probably caused, as in this instance, by antipyrin. (2) Woman, 54: Ten grains of antipyrin caused temporary blindness, unconsciousness, convulsions, and symptoms of collapse.—"Notes on two cases of poisoning from antipyrin," by D. G. Newton, in Quarterly Medical Journal, Sheffield, 1897–98, vol. 6, p. 133.

The ingestion of 5 grains of antipyrin by a young woman was followed by the appearance of an eruption resembling hives and disagreeable nervous symptoms, including excessive sneezing, shortness of breath, profuse sweating, coppery taste and smell, ringing in the ears, etc.—"Idiosyncrasy with regard to antipyrin: A warning," by W. A. Sturge, in British Medical Journal, London, 1888, vol. 1, p. 243.

Woman, 53: A dose of 5 grains of antipyrin was followed by shortness of breath, an eruption resembling hives, swelling of the lips and tongue, unconsciousness, and symptoms of collapse. On the third day a white membrane formed upon the tongue, lips, and pharynx, and soon after 13 abscesses the size of a chestnut or smaller developed in the mouth. On two subsequent occasions the use of 5 grains of the drug was followed by similar symptoms.—"A case of antipyrin poisoning, with the formation of membranes in the mouth, and symptoms of *Laryngismus stridulus*," by J. L. Salinger, in American Journal of the Medical Sciences, Philadelphia, 1890 (n. s.), vol. 99, p. 489.

PHENACETIN.

Number of cases and their distribution.—From the year 1887 to the close of 1907, 70 or more cases of poisoning by phenacetin were recorded in medical publications by 41 observers. Of the total number of cases, 3, or 4.2 per cent, are reported to have terminated fatally. This number, 70, is notably less than the recorded number of cases of poisoning by either acetanilid or antipyrin, and this fact tends to substantiate the common belief that of the three drugs this is, under ordinary circumstances, the least likely to produce ill effects.

The number of cases of poisoning recorded in each year since the introduction of phenacetin as a medicine, together with the number of observers, is shown in the following table:

Cases of phenacetin poisoning recorded annually, 1887–1907.

[No cases recorded for years omitted.]

Year.	Number of cases.	Number of observers.	Year.	Number of cases.	Number of observers.	Year.	Number of cases.	Number of observers.
1887	1	1	1893	2	1	1903	1	1
1888	23	10	1894	3	3	1904	2	2
1889	11	6	1895	6	4	1905	2	2
1890	6	3	1896	1	1	1907	1	1
1891	5	2	1899	1	1			
1892	4	2	1901	1	1	Total	70	41

It will be seen that 23, or 32.8 per cent, of all the cases were recorded during the year following the introduction of phenacetin as a medicine in 1887, and that 40, or 57.1 per cent, were recorded during the years 1888, 1889, and 1890. The large proportion of cases recorded during this period was undoubtedly due in part, as in case of acetanilid and antipyrin, to the fact that at this time the depressing effect of phenacetin was not fully appreciated. After the year 1890 the number of cases of poisoning recorded annually was, on the average, only two or three cases, and the number appears to have decreased rather than increased as the years passed.

Discussion of symptoms.—The ill effect which appears to occupy the place of greatest importance in the recorded cases of poisoning by phenacetin is general weakness. Other symptoms noted were vomiting, blueness of the skin, rapid and weak pulse, shortness of breath, cold perspiration, great restlessness, an eruption on the skin, and disturbance of the action of the kidneys.

Abstracts of phenacetin cases.—The following abstracts illustrate the symptoms in cases of poisoning by phenacetin:

Woman: Had been addicted to the phenacetin habit for about seven months, daily quantity being between 15 and 20 grains. Addiction was discovered by her husband when her supply of the drug gave out and the local pharmacist also ran out of a supply temporarily. Violent convulsive and hysterical seizures followed and continued until phenacetin was secured for her. Pulse, 170, and very weak. Respiration rapid and spasmodic. Pupils widely dilated; pallor, cold perspiration. She had more than a dozen convulsions and vomited freely. Before beginning the habit she was "a healthy, buxom country girl." Examination made after the attack above described showed some anemia, complexion bad, circulation weak, pulse 124, sleep restless and troubled, digestion impaired, occasional vertigo.—"A report of three cases of addiction to coal-tar derivatives," by J. S. Davis, in American Medical and Surgical Bulletin, 1894, vol. 7, p. 1490.

Boy, 17: After taking 15-grain doses of phenacetin for headache for three weeks, a dose caused vomiting, followed on the next day by great weakness, blueness of the face, weak pulse, and diarrhea. Jaundice followed, and the blueness spread to the extremities. The urine consisted of almost pure blood. Death occurred after two days.—"Phenacetin poisoning with fatal result," by G. Krönig, in Berliner klinische Wochenschrift, 1895, vol. 32, p. 998.

Woman, 34: Soon after taking 15 grains of phenacetin she felt dizzy, cold, and nauseated. Her headache became worse, and after three hours she took another phenacetin powder. This was followed by an aggravation of the symptoms; the nausea and sensation of chilliness increased, the hands, lips, and cheeks were deep blue, and there was cold perspiration and shortness of breath.—"Distressing poisonous side-effects of phenacetin," by Lindmann, in Therapeutische Monatshefte, Berlin, 1888, vol. 2, p. 307.

On Friday, December 13, 1907, at 9.20 p. m., a girl of 16.5 years, in good general health, but having a headache and feeling that she had taken cold, took 2 headache tablets and went to bed. Later, her mother heard her coughing and went to her. There was nothing at this time to cause alarm, but a little before 11 o'clock the girl's lips and face began to become blue, and in consequence a physician was sent for. He responded at once, and found the girl with great weakness of the heart. Before he could administer any remedy she was dead.

The box with the remaining tablets was sent to the office of the state board of health for examination. The tablets were found to contain phenacetin.—"Fatal poisoning by phenacetin in headache tablets," by George L. Tobey, in Monthly Bulletin of the State Board of Health of Massachusetts, January, 1908.

The taking of 15 grains of phenacetin every two hours for twenty-four hours was followed by extreme weakness and then by symptoms of collapse, with tendency to fainting, dizziness, shortness of breath, blueness of the hands and feet, pain around the heart, nausea, and a rapid and feeble pulse. The skin was of a yellowish gray color and the next day an eruption appeared. Recovery after five days.—"Contribution to the study of the poisonous nature of phenacetin," by J. Meurice, in Annales de la société de médecine de Gand, 1905, vol. 85, p. 199.

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FARMERS' BULLETIN 378.

METHODS OF EXTERMINATING THE TEXAS-FEVER TICK.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., July 22, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Methods of Exterminating the Texas-fever Tick," by H. W. Graybill, scientific assistant in the Zoological Division of this Bureau.

For many years these ticks, which transmit the disease of cattle known as Texas or tick fever, have been a cause of heavy loss and a great handicap to live-stock raising in the southern part of the United States. The progress so far made, however, in the cooperative campaign by this Department and State authorities with the object of completely eradicating this pest from the country demonstrates that it is entirely possible to accomplish that result, although a number of years of hard work will be required. It is of great importance for the success of this undertaking that the efforts of the officials should be supplemented by individual work by the farmers. This paper gives simple and practical directions for exterminating the ticks, and I respectfully recommend its publication in the popular Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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METHODS OF EXTERMINATING THE TEXAS-FEVER TICK.

INTRODUCTION.

The eradication of the cattle tick (*Margaropus annulatus*) from the Southern States is a problem of prime importance to the agricultural interests of that section. Moreover, the good that would result from the elimination of the tick would not be entirely confined to the region directly concerned, and thus the matter assumes to a certain degree a national importance.

A number of valuable papers on the life history of the cattle tick, its habits, and methods for its eradication have been published by the United States Department of Agriculture and by various investigators in the States included within the infested region. Some of these publications are rather extensive and include much that is only of scientific interest, while others, of a more practical nature, are not available for general use. The present bulletin is prepared with the view of bringing together from these various sources information of practical value relating to the tick and its eradication, for the use of the farmer or stockman who has begun or who contemplates undertaking the complete extermination of this pest from his farm. Some unpublished results of investigations carried on by the writer in connection with the cooperative work between the Zoological Division of the Bureau of Animal Industry and the veterinary department of the Alabama Polytechnic Institute have also been taken into consideration.

REASONS FOR ERADICATING THE CATTLE TICK.

There are various kinds or species of ticks occurring on cattle in the Southern States, but the one that chiefly concerns us here is that commonly called the "cattle" or "Texas-fever" tick (*Margaropus annulatus*). It is the one most frequently found on cattle and is much more abundant than the other species. When the losses occasioned by this parasite are once thoroughly understood by farmers and stockmen there will be little need for arguments in favor of tick eradication. Some of the losses are not directly noticeable and consequently make little impression, while other losses properly chargeable to the tick are frequently attributed to other causes.

It is hardly necessary to emphasize the important fact that the tick is something more than a simple parasite drawing blood from its host, it being the carrier of a dangerous micro-organism or germ, which it transmits to the blood of cattle, thus causing a disease known by many names, among which are Texas fever, tick fever, splenetic fever, and murrain.[a] Without the tick there can be no Texas fever, and it is by preventing the spread of the tick beyond its natural bounds that the fever has been prevented from waging destruction among northern cattle, which are especially susceptible to the disease. In order to restrict the distribution of the tick the National and State governments maintain a quarantine line extending from the Atlantic to the Pacific coast, marking the boundary between the States or portions of States harboring this pest and those that do not. Cattle of the quarantined area can not be driven across this line, and may be shipped only in accordance with the regulations of the Secretary of Agriculture to prevent the spread of splenetic fever of cattle.

The more important losses for which the tick is responsible are as follows:

1. Deaths from tick fever among native cattle and purebred cattle imported from the North for breeding purposes.
2. Deaths of cattle north of the quarantine line from fever following the occasional accidental introduction of the tick.
3. The temporary and permanent arrest of growth and development resulting from attacks of the fever.
4. The decrease in weight and the lessened rate in putting on flesh in the case of beef cattle, and the decrease in the amount of milk produced by dairy cattle, as the result of the irritation and loss of blood occasioned by great numbers of ticks.
5. The prevention of southern breeders from exhibiting their stock in the North.
6. The decreased price that southern cattle bring on the market on account of the restrictions placed upon them.
7. The considerable expense incurred each year by the Federal Government and the infested States in establishing quarantine lines and in enforcing regulations to prevent the spread of Texas fever.

Various writers have estimated the annual loss due to the tick at from $40,000,000 to $100,000,000. These figures should be ample argument, even to the most conservative, for the eradication of the tick.

The South needs more and better live stock and a larger and better dairy industry, and these objects would both be greatly promoted by the destruction of the tick. Furthermore, the increased production of live stock, by reason of its important bearing in maintaining and improving the fertility of the soil, would be of distinct benefit in increasing the yield of field crops. An incidental though important advantage of stock raising and dairying would be found in the distribution of the farmer's income throughout the year, enabling him to live on a cash basis. It can thus be seen that the benefits which would accrue to southern agriculture from the extermination of the cattle tick would be very great and far-reaching.

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[a] For information as to this disease and how it is transmitted by the ticks the reader is referred to Farmers' Bulletin 258, "Texas or Tick Fever and Its Prevention."

LIFE HISTORY OF THE TICK.

Before methods of eradication can be carried out intelligently and successfully, it is necessary to know the life history of the tick, and the influence of temperature, moisture, and other climatic conditions on the various stages of its existence. These matters will therefore be taken up first, it being understood that whenever the term "tick" or "cattle tick" is used, it refers to the one species or kind, *Margaropus annulatus*.[a]

The usual host for this tick is the cow or ox. Frequently, however, horses, mules, deer, and sometimes even sheep serve as hosts. But none of these latter animals, with the possible exception of deer, are susceptible to tick fever, consequently they suffer from the tick as a simple parasite and not as a transmitter of disease, although they must be considered in plans for eradication.

Only a part of the development of the tick takes place on the host; the rest of the development occurs on the pasture occupied by the host.

DEVELOPMENT ON THE GROUND.

In tracing the life history of the cattle tick it will be convenient to begin with the large, plump, olive-green female tick (fig. 1), somewhat more than half an inch in length, attached to the skin of the host. During the few preceding days she has increased enormously in size as a consequence of drawing a large supply of blood.

When fully engorged she drops to the ground, and at once, especially if the weather is warm, begins to search for a hiding place on moist earth beneath leaves or any other litter which may serve as a protection from the sun and numerous enemies. The female tick may be devoured by birds or destroyed by ants, or may perish as the result of unfavorable conditions, such as low temperature, absence or excess of moisture, and many other conditions; so that many which fall to the ground are destroyed before they lay eggs.

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[a] The reader desiring fuller information as to the life history of the cattle tick is referred to Bulletin 72 of the Bureau of Entomology, United States Department of Agriculture, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents.

Egg laying (see fig. 2) begins during the spring, summer, and fall months in from two to twenty days, and during the winter months in thirteen to ninety-eight days. The eggs are small, elliptical-shaped bodies, at first of a light amber color, later changing to a dark brown, and are about one-fiftieth of an inch in length. As the eggs are laid they are coated with a sticky secretion which causes them to adhere in clusters and no doubt serves the purpose of keeping them from drying out. During egg laying the mother tick gradually shrinks in size and finally is reduced to about one-third or one-fourth her original size. Egg laying is greatly influenced by temperature, being retarded or even arrested by low temperatures. It is completed in from four days in the summer to one hundred and fifty-one days beginning in the fall. During this time the tick may deposit from a few hundred to more than 5,000 eggs. After egg laying is completed the mother tick has fulfilled her purpose and dies in the course of a few days.

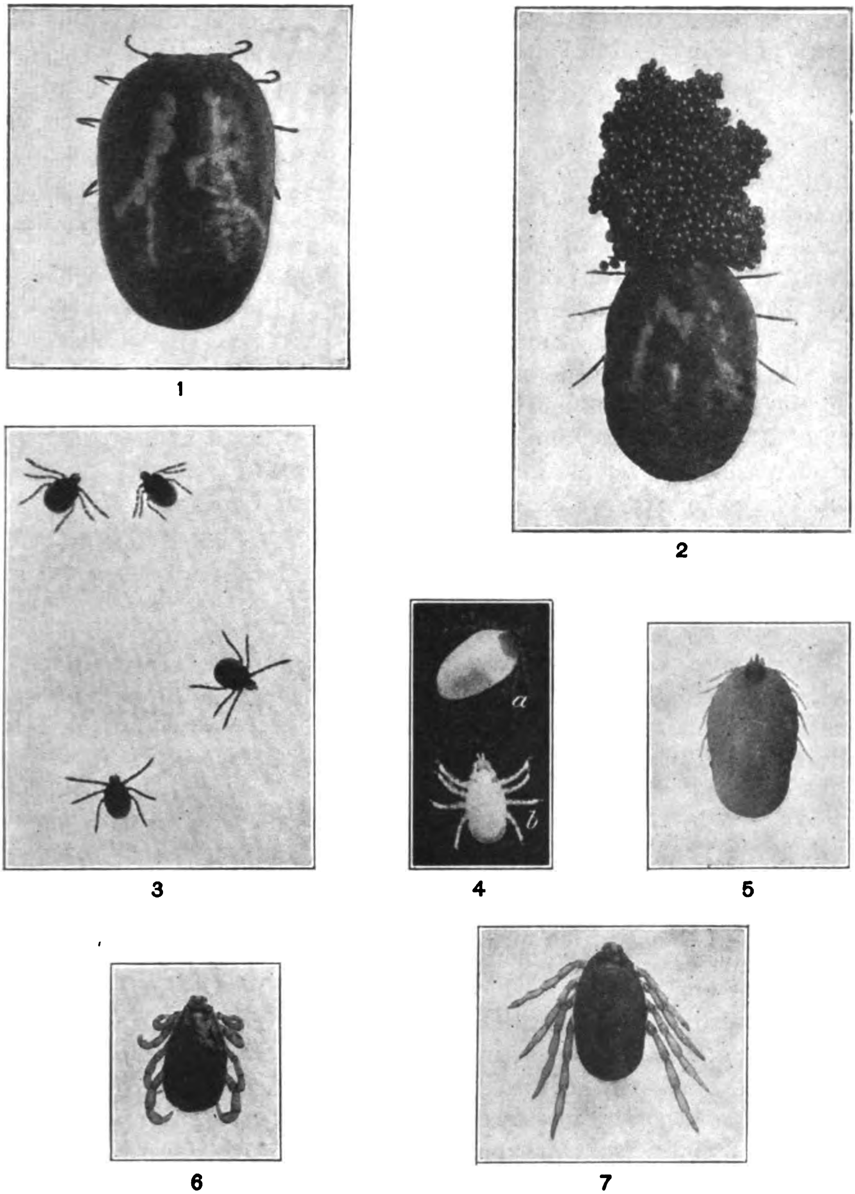
After a time, ranging from nineteen days in the summer to one hundred and eighty-eight days during the fall and winter, the eggs begin to hatch. From each egg issues a small, oval, six-legged larva or seed tick (fig. 3), at first amber colored, later changing to a rich brown. The seed tick, after crawling slowly over and about the shell from which it has emerged, usually remains more or less quiescent for several days, after which it shows great activity, especially if the weather is warm, and ascends the nearest vegetation, such as grass, other herbs, and even shrubs.

Since each female lays an enormous mass of eggs at one spot, thousands of larvæ will appear in the course of time at the same place and will ascend the near-by vegetation and collect on the leaves. This instinct of the seed ticks to climb upward is a very important adaptation to increase their chances of reaching a host. If the vegetation upon which they rest is disturbed, they become very active and extend their long front legs upward in a divergent position, waving them violently in an attempt to seize hold of a host.

The seed tick during its life on the pasture takes no food and consequently does not increase in size, and unless it reaches a host to take up the parasitic portion of its development, it dies of starvation. The endurance of seed ticks is very great, however, as they have been found to live nearly eight months during the colder part of the year.

DEVELOPMENT ON CATTLE.

The parasitic phase of development begins when the larvæ or seed ticks reach a favorable host, such as a cow. They crawl up over the hair of the host and commonly attach themselves to the skin of the escutcheon, the inside of the thighs and flanks, and to the dewlap. They at once begin to draw blood and soon increase in



FIGS. 1 to 7.—Cattle ticks in various stages. 1. Full-grown female tick, engorged and ready to drop to ground and deposit eggs. (Magnified 3 times.) 2. Tick laying eggs. One tick may lay as many as 5,000 eggs. (Magnified 3 times.) 3. Larvæ or seed ticks after emerging from eggs. (Magnified 9 times.) 4. Young ticks before (*a*) and after (*b*) first molt. At this stage the ticks have attached themselves to a host (cow, steer. etc.), and have changed from a brown color to white. It will be noticed that the tick has six legs before molting and eight afterwards. (Magnified 9 times.) 5. Young tick nearly ready to undergo the second molt. The tick at this stage is known as a nymph. (Magnified 6 times.) 6. Male tick. (Magnified 6 times.) 7. Female tick after second molt. This tick is now sexually mature and slightly larger than the male, but will later greatly increase in size until ready to drop to the ground and deposit eggs. (Magnified 6 times.)

size. In a few days the young tick changes from a brown color to white (fig. 4, *a*), and in from five to twelve days sheds its skin. The new form has eight legs instead of six, and is known as a nymph (fig. 4, *b*, and fig. 5).

In from five to eleven days after the first molt the tick again sheds its skin and becomes sexually mature. It is at this stage that males and females are with certainty distinguishable for the first time. The male (fig. 6) emerges from his skin as a brown, oval tick, about one-tenth of an inch in length. He has reached his growth and goes through no further development. He later shows great activity, moving about more or less over the skin of the host. The female (fig. 7) at the time of molting is slightly larger than the male. She never shows much activity, seldom moving far from her original point of attachment. She still has to undergo most of her growth. After mating the female increases very rapidly in size, and in from twenty-one to sixty-six days after attaching to a host as a seed tick she becomes fully engorged (fig. 1) and drops to the pasture, to repeat the cycle of development.

SUMMARY OF LIFE HISTORY.

To sum up, on the pasture there are found three stages of the tick—the engorged female, the egg, and the larva; and on the host are found four stages—the larva, the nymph, the sexually mature adult of both sexes, and the engorged condition of the female.

METHODS OF ERADICATION.

In undertaking measures for eradicating the tick it is evident that the pest may be attacked in two locations, namely, on the pasture and on the cattle.

In freeing pastures the method followed may be either a direct or an indirect one. The former consists in excluding all cattle, horses, and mules from pastures until all the ticks have died from starvation. The latter consists in permitting the cattle and other animals to continue on the infested pasture and treating them at regular intervals with oils or other agents destructive to ticks and thus preventing engorged females from dropping and reinfesting the pasture. The larvæ on the pasture, or those which hatch from eggs laid by females already there, will all eventually meet death. Such of these as get upon the cattle from time to time will be destroyed by the treatment, while those which fail to find a host will die in the pasture from starvation.

Animals may be freed of ticks in two ways. They may be treated with an agent that will destroy all the ticks present, or they may be rotated at proper intervals on tick-free fields until all the ticks have dropped.

TIME REQUIRED TO KILL TICKS BY STARVATION.

The time required for the ticks to die out after all animals have been removed from infested fields and pastures varies considerably, depending principally on climatic and weather conditions. The dates when pastures will be free of ticks, beginning during each month of the year, are given in the following table:

Time required to free pastures from ticks by starvation.

Date of removal of all animals from pasture.	Date when pasture will be free from ticks.	Date of removal of all animals from pasture.	Date when pasture will be free from ticks.
July 1	March 1.	December 15 to March 15, inclusive.	September 1.
August 1	May 1.	April 1	September 15.
September 1	July 1.	April 15	October 15.
October 1 to November 1, inclusive.	August 1.	May 1 to June 15, inclusive	November 1.
December 1	August 15.		

The above table is based on investigations by Hunter and Hooker [a] at Dallas, Tex., and by the writer at Auburn, Ala., under cooperation between the Bureau of Animal Industry and the veterinary department of the Alabama Polytechnic Institute. All the periods obtained by Newell and Dougherty (1906) [b] in work carried on at Baton Rouge, La., which is much farther south, are shorter. The above periods should be found ample for all localities lying no farther north than Dallas, Tex., or Auburn, Ala. The periods necessary to starve out an infestation for many localities in the southern part of the infested region are no doubt somewhat shorter than those given above. In general, moisture and cold prolong and dryness and heat shorten the duration of an infestation. If various portions of the same pasture differ with regard to temperature and moisture, as is frequently the case, some parts become free of ticks before others do. Other things being equal, high, dry, unshaded land becomes tick free sooner than low, damp, shady land.

The simplest and safest plan in most cases, however, will be to follow the foregoing table in the region indicated for it. It is probable that the periods given in the table should be lengthened a little for the northern part of the infested region. The experiments conducted thus far in various places indicate this and it will place the eradication work in that region on the safe side. For example, E. C. Cotton [c] obtained at Knoxville, Tenn., records for September and April somewhat longer than those given above. They are as follows:

Cattle removed April 15; pasture free of ticks November 13.
Cattle removed September 15; pasture free of ticks July 18.

In localities with temperature and other conditions similar to those at Knoxville, Tenn., these periods should be followed.

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[a] Bulletin 72, Bureau of Entomology, U. S. Department of Agriculture.

[b] Circular 10, State Crop Pest Commission of Louisiana.

[c] Bulletin 81, Agricultural Experiment Station of the University of Tennessee.

TIME REQUIRED TO RENDER CATTLE FREE OF TICKS WHEN PLACED ON UNINFESTED FIELDS.

Before discussing plans for rendering farms tick-free, involving the use of the information given in the foregoing table, it will be necessary to indicate how animals may be entirely freed from ticks by placing them on uninfested fields. This is based on the fact that the female tick must drop from the host to the ground before eggs can be laid and before young ticks will develop.

The shortest time in which seed ticks will appear after engorged females have been dropped is twenty days. Consequently cattle placed on a tick-free field during the warmer part of the year are not in danger of becoming infested again with young ticks until twenty days have elapsed. The time required for all the ticks to drop after cattle have been placed on uninfested land varies with the temperature. It is much longer during the winter than during the summer. The time required, beginning at various times of the year, is given in the following table:

Time required for all ticks to drop from cattle placed on tick-free land.

When ticky cattle are placed on tick-free land during—	All ticks will have dropped in—	When ticky cattle are placed on tick-free land during—	All ticks will have dropped in—
August	Six weeks.	March	Seven weeks.
September	Do.	April	Six weeks.
October	Eight weeks.	May	Do.
November	Nine weeks.	June	Do.
January	Ten weeks.	July	Five weeks.
February	Seven weeks.		

FREEING CATTLE OF TICKS BY ROTATION ON TICK-FREE LAND.

The plan of freeing cattle of ticks by rotating them from one lot or field to another is as follows: Beginning at any time of the year from February to September, inclusive, the cattle are removed from the tick-infested pasture they have been occupying to a tick-free lot or field, and continued there for not more than twenty days. During this time a considerable number of ticks will drop. In order to prevent the cattle from becoming reinfested (by seed ticks resulting from eggs laid by females that have dropped), the herd is then changed to a second tick-free inclosure for twenty days longer, and if they are not free of ticks by that time they are placed in a third tick-free inclosure for twenty days more. Should the two changes at intervals of twenty days have been made, sixty days will have elapsed, which is ample time for all ticks to have dropped during the portion of the year indicated, and the animals are ready to be placed on a tick-free pasture or field without danger of becoming reinfested. The periods to free cattle (given in the above table) are believed to be ample. It will, however, be a wise precaution to make a careful examination of the cattle for ticks before placing them in the non-infested field they are to occupy.

During the part of the year from October to January, inclusive, the time required for seed ticks to appear after females have dropped is much longer than the time necessary for all the ticks to drop from cattle. Consequently, if it is desired, the herd may be continued on the same field for the required length of time without danger of becoming reinfested.

FREEING BOTH CATTLE AND PASTURES OF TICKS BY THE ROTATION METHOD.

The particular scheme of rotation to be followed on a farm depends much on the conditions which have to be met. In figures 8 to 11 four plans of rotation are represented. In these diagrams no attempt has been made to indicate, except in a very rough way, the relative size of the fields, since this depends on the number of cattle and on various conditions of a more or less local nature. It rests with the farmer to select his fields with regard to location and size so as to carry out properly and successfully the plan which he adopts.

The matter of the dissemination of ticks deserves particular attention in considering rotation methods. The engorged females which drop on a pasture will crawl at most only a few feet. The same may be said of the larvæ or seed ticks. It is possible, however, for seed ticks to be passively carried considerable distances at times. Dogs, cats, and other animals which ordinarily pass unhindered over farms may become covered with seed ticks while going through one field, and later some of these may be brushed off the animal while passing through the herbage of an adjoining field. Even though the danger of ticks being spread in this manner is not great, it will be well, when practicable, to take precautions against it.

Again, engorged females, eggs, and seed ticks may be carried by running water from a pasture without being injured in any way. The danger from this source is probably greatest where there are many small streams subject to frequent floods of short duration and on hillsides where the water runs off with great force during heavy rains. This will, no doubt, in some localities present a rather serious problem in tick eradication.

Ticks may crawl from the edge of one pasture into an adjoining pasture, or engorged females may drop from the heads of animals reaching through a dividing fence. These difficulties are best overcome by constructing a double fence with an intervening space of 15 feet. Such a double fence, if the land does not slope greatly, will also greatly reduce the danger of ticks being washed from one pasture to the other during rains.

Plan requiring four and one-half months.—The plan of rotation represented in figure 8 requires four and a half months for its completion. Some time during the spring the pasture is divided in the middle by two lines of temporary fence 15 feet apart. The herd is first confined in field No. 1A. On June 15 it is moved from this portion of the pasture to the other portion, designated field No. 1B, and on September 2 is moved to field No. 2A. The cattle are permitted to remain twenty days on each of the fields designated 2A, 2B, and 3. At the end of this time (November 1) all the ticks on the cattle have dropped, and the herd is returned to field No. 1A, which in the meantime has become free of ticks. Later, if it is desired, the cattle may be placed in field No. 4. They should not, however, be returned to any of the other fields or driven across them, since these are infested with ticks. Field No. 1B will be free from ticks July 1 of the following year, at which time the temporary double fence may be removed and the cattle allowed to graze over the entire pasture. The rest of the farm will be free of ticks by August 1. If found desirable, the herd may be continued longer in field No. 3, even as late as February 15, the only objection to this being that it will break the crop rotation by preventing the sowing of oats in the fall.

It is well, when practicable, to have double fences with an intervening space of 15 feet between the different fields in order to prevent the ticks getting from one field to another. If this is not possible on account of the expense and time required to build the extra line of fence, the next best thing is to throw up with a plow several furrows on each side of the dividing fences.

When there are streams running through the farm or the slope of the land is considerable, so that ticks may be washed from one field to the other during rains, the fields should be so arranged or selected that the drainage is from field No. 1A to No. 1B, and from field No. 3 toward fields Nos. 2A and 2B.

Plan requiring eight months.—The plan indicated in figure 9 is begun fifteen days later than the preceding one and requires eight months for its completion. The pasture is divided as before. The herd is moved July 1 from field No. 1A to No. 1B, and on October 15 is moved from there to field No. 2. The herd may be continued on fields Nos. 2 and 3 until February 15 in any way found most convenient, since there is no danger of young ticks hatching during that time. The herd is moved not later than February 15 to field No. 4. All the ticks on the cattle will have dropped by December 20, consequently the herd may be moved to field No. 4 as early as that date, if found desirable.

By March 1 the original pasture is free and the cattle are returned there. Field No. 1B will be free of ticks by August 1, at which time the double fence separating the two parts of the pasture may be removed. The rest of the farm will not be certainly free of ticks until September 1. The drainage in general should be from field No. 1A toward No. 1B, and from field No. 4 toward field No. 2.

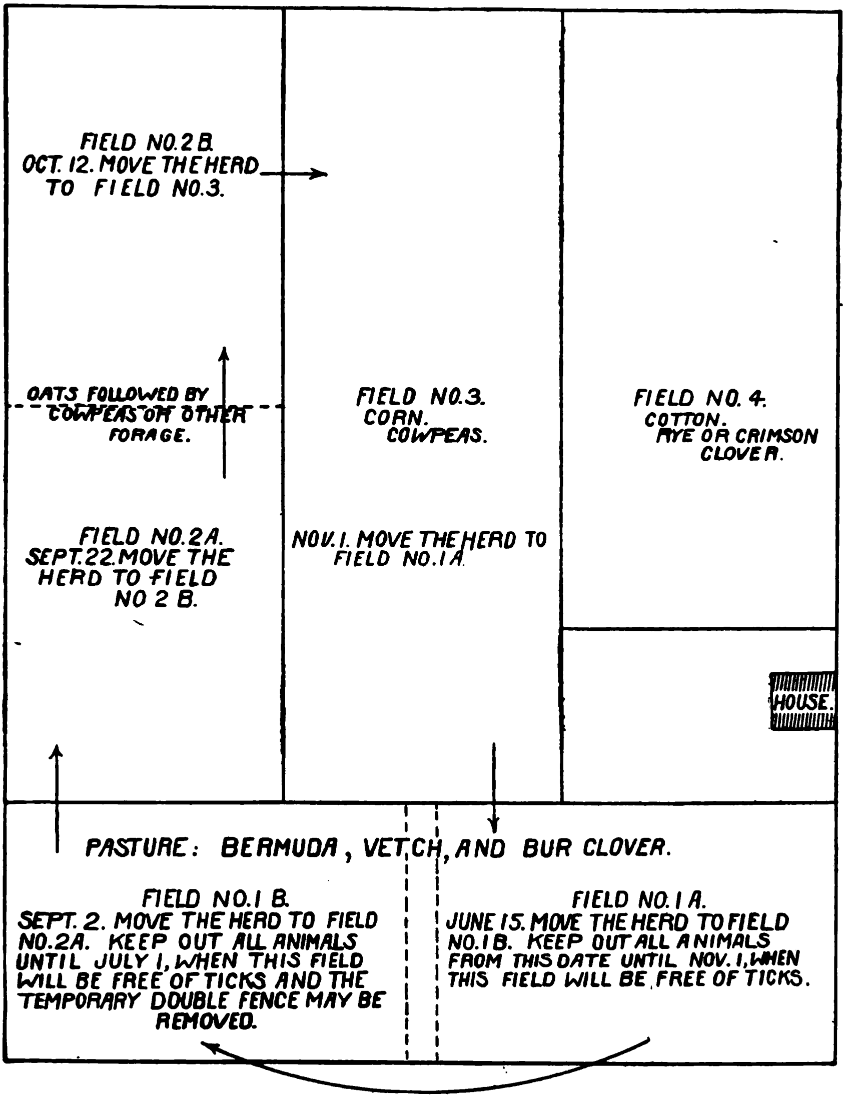
FIELD NO. 2 B.
OCT. 12. MOVE THE HERD TO FIELD NO. 3.
OATS FOLLOWED BY COWPEAS OR OTHER FORAGE.
FIELD NO. 2 A.
SEPT. 22. MOVE THE HERD TO FIELD NO 2 B.
FIELD NO. 3.
CORN.
COWPEAS.
NOV. 1. MOVE THE HERD TO FIELD NO. 1 A.
FIELD NO. 4.
COTTON.
RYE OR CRIMSON CLOVER.
HOUSE.
PASTURE: BERMUDA, VETCH, AND BUR CLOVER.
FIELD NO. 1 B.
SEPT. 2. MOVE THE HERD TO FIELD NO. 2 A. KEEP OUT ALL ANIMALS UNTIL JULY 1, WHEN THIS FIELD WILL BE FREE OF TICKS AND THE TEMPORARY DOUBLE FENCE MAY BE REMOVED.
FIELD NO. 1 A.
JUNE 15. MOVE THE HERD TO FIELD NO. 1 B. KEEP OUT ALL ANIMALS FROM THIS DATE UNTIL NOV. 1, WHEN THIS FIELD WILL BE FREE OF TICKS.

FIG. 8.—Plan for freeing cattle and pastures from ticks by rotation, requiring four and one-half months.

Plan requiring four months, with a new pasture.—The plan of rotation represented in figure 10 involves changing the location of the pasture. The oat field (field No. 4) after the grain has been harvested is reserved for this purpose. It should be sown in cowpeas, Bermuda grass, and bur clover. The herd is moved October 15 from the original pasture, field No. 1, to field No. 2, where it may be kept for a month or two, or until the feed becomes short, then moved to field No. 3, where it is kept until February 15, when it is moved to the new pasture, field No. 4. The old pasture may be planted in oats. The drainage should be from field No. 4 toward field No. 2.

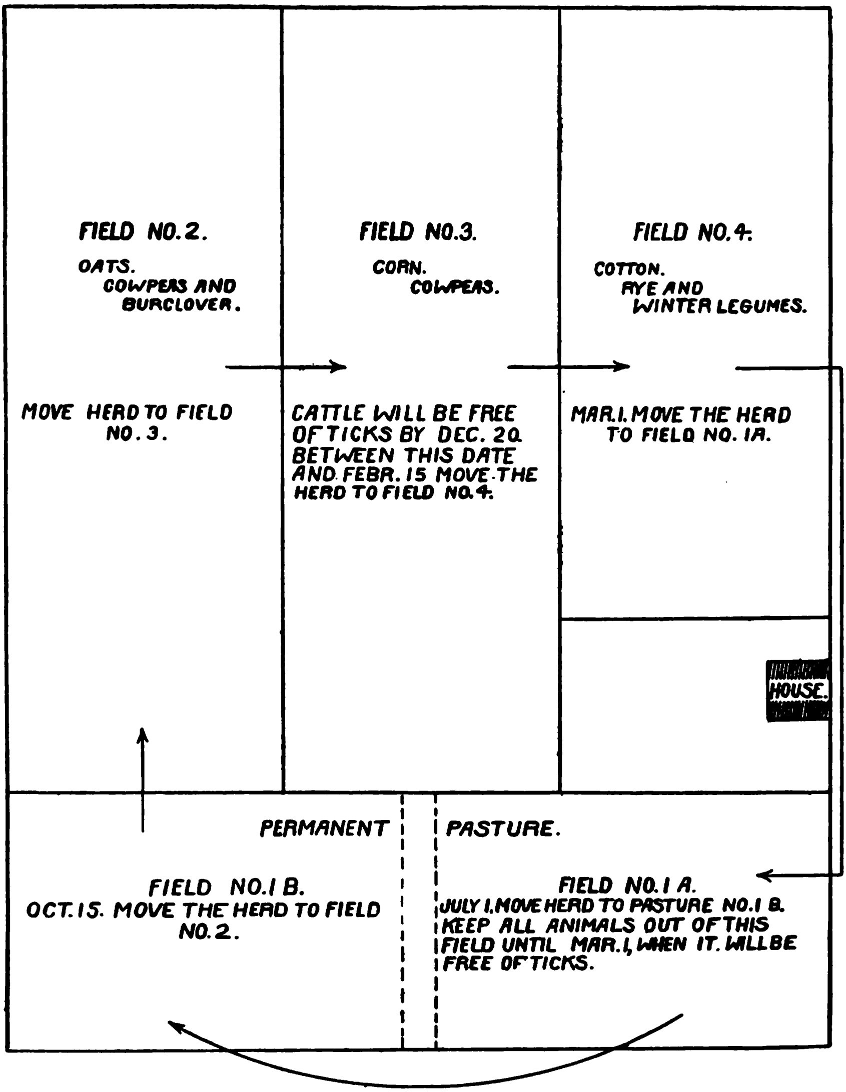
FIELD NO. 2.
OATS.
COWPEAS AND
BURCLOVER.
FIELD NO. 3.
CORN.
COWPEAS.
FIELD NO. 4.
COTTON.
RYE AND
WINTER LEGUMES.
MOVE HERD TO FIELD NO. 3.
CATTLE WILL BE FREE OF TICKS BY DEC. 20. BETWEEN THIS DATE AND FEBR. 15 MOVE THE HERD TO FIELD NO. 4.
MAR. 1. MOVE THE HERD TO FIELD NO. 1A.
HOUSE.
PERMANENT
PASTURE.
FIELD NO. 1 B.
OCT. 15. MOVE THE HERD TO FIELD NO. 2.
FIELD NO. 1 A.
JULY 1, MOVE HERD TO PASTURE NO. 1 B. KEEP ALL ANIMALS OUT OF THIS FIELD UNTIL MAR. 1, WHEN IT WILL BE FREE OF TICKS.

FIG. 9.—Plan for freeing cattle and pastures from ticks by rotation, requiring eight months.

The feed-lot or soiling method, requiring four and one-half months.—In the plan given in figure 11 the feed-lot or soiling method is made use of to free the cattle of ticks. In the spring field No. 3B, located near the farmyard, is sown in corn for a soiling crop. The area devoted to corn should be sufficient to supply feed for the herd for five or six weeks. Field No. 3A, after the oats are harvested, should be sown in sorghum and cowpeas or millet and cowpeas, and should be large enough to furnish feed for the herd until November 1. These fields should not have had cattle on them for at least ten months.

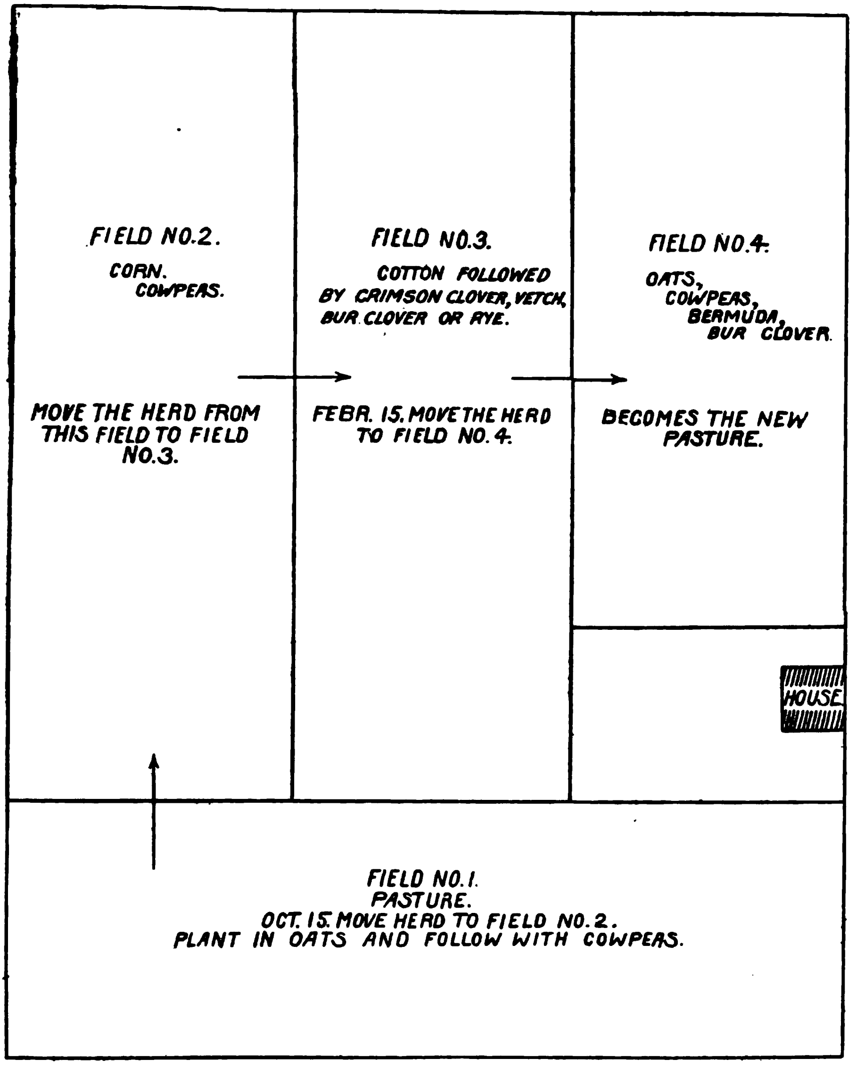
FIELD NO.2.
CORN.
COWPEAS.
MOVE THE HERD FROM THIS FIELD TO FIELD NO.3.
FIELD NO.3.
COTTON FOLLOWED BY CRIMSON CLOVER, VETCH, BUR CLOVER OR RYE.
FEBR. 15. MOVE THE HERD TO FIELD NO. 4.
FIELD NO.4.
OATS,
COWPEAS,
BERMUDA,
BUR CLOVER.
BECOMES THE NEW PASTURE.
HOUSE
FIELD NO.1.
PASTURE.
OCT. 15. MOVE HERD TO FIELD NO. 2.
PLANT IN OATS AND FOLLOW WITH COWPEAS.

FIG. 10.—Plan for freeing cattle and pastures from ticks by rotation, requiring four months, with new pasture.

Previous to June 15 three lots, each large enough to accommodate the herd, are fenced off in field No. 3B. These lots should not be located on a stream, and the drainage should be from field No. 3A toward field No. 3B. There should be a space of 15 feet or more between the lots. On June 15 the herd is moved to lot No. 1, and afterwards to lots Nos. 2 and 3 at intervals of twenty days. After the cattle have spent the required time in lots Nos. 1 and 2, if it is found after a careful examination made by some one familiar with such work that the cattle are free of ticks, they may be turned directly into field No. 3A. If they are not free they should be placed in lot No. 3 until they are free, or, if this can not be determined with certainty, until fifteen or twenty days more have elapsed, which will be much longer than necessary for all ticks to drop during July and August.

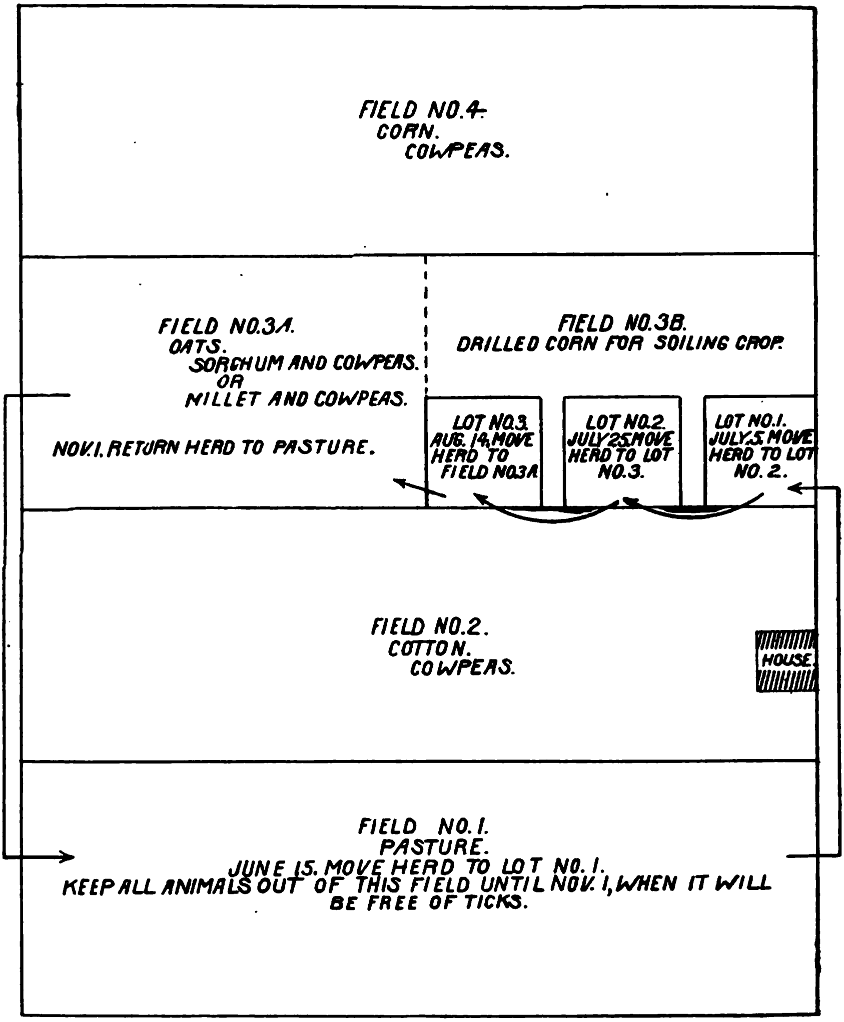
FIELD NO.4.
CORN.
COWPEAS.
FIELD NO.3A.
OATS.
SORGHUM AND COWPEAS.
OR
MILLET AND COWPEAS.
NOV.1. RETURN HERD TO PASTURE.
FIELD NO.3B.
DRILLED CORN FOR SOILING CROP.
LOT NO.3.
AUG. 14. MOVE HERD TO FIELD NO.3A.
LOT NO.2.
JULY 25. MOVE HERD TO LOT NO.3.
LOT NO.1.
JULY 5. MOVE HERD TO LOT NO. 2.
FIELD NO.2.
COTTON.
COWPEAS.
HOUSE.
FIELD NO.1.
PASTURE.
JUNE 15. MOVE HERD TO LOT NO. 1.
KEEP ALL ANIMALS OUT OF THIS FIELD UNTIL NOV. 1, WHEN IT WILL BE FREE OF TICKS.

FIG. 11.—Plan for freeing cattle and pastures from ticks by rotation; feed-lot or soiling method.

If desirable, the corn in each lot may be cut and removed before the cattle are placed in it. As soon as possible after the cattle are removed from a lot the female ticks and eggs present on the ground should be plowed under and the ground along the fence sprayed with crude petroleum or some other disinfectant to prevent any seed ticks which may hatch from getting beyond the area of the lot. Another valuable precaution will be to use for feed, as far as possible, the corn opposite or in advance of the lot in which the cattle are located, since this is less likely to harbor seed ticks.

The pasture will be free of ticks by November 1, and the cattle may then be returned there if desired. The herd may, however, be continued on field No. 3A as long after that date as the forage lasts, or, in case of a shortage of feed previous to November 1, it may be moved to either field No. 2 or 4, provided one of these is ready for pasturage. These fields may be used for fall and winter pasturage in any way that may be found desirable.

DIPPING, SPRAYING, AND HAND DRESSING.

Ticks upon cattle may be destroyed by using various "tickicides," such as oils, arsenic, etc. These may be applied in three ways, namely, by hand, by the use of spray pumps, and by means of the dipping vat.

Hand application is practicable only when a few animals are to be treated. The substances of value in this method are a mixture of lard and kerosene, cotton-seed oil, or a half-and-half mixture of cotton-seed oil and kerosene, and finally, crude petroleum, which in general has proved the most effective, although it has some drawbacks, chief of which are the difficulty of obtaining oil of the proper quality, its expense, its bulk, which makes its transportation costly, and the liability of injury to cattle when the treatment is applied in hot weather. Any of these may be applied with a mop or a good-sized paint brush, but unless great pains are taken this method of treatment is not thorough, and even at the best some portions of the body where ticks may be located will be missed.

Spraying is adapted for small-sized herds. The arsenical mixture or the crude petroleum or emulsions of the same may be applied by means of an ordinary pail spraying pump (fig. 12). There are also pumps on the market designed for making a temporary mechanical mixture of oil and water. Cotton-seed oil, or cotton-seed oil and kerosene in a half-and-half mixture, or crude petroleum, may be used in these pumps, and a 20 per cent mixture of any one of these will kill most of the ticks.

A large spraying machine which is now on the market and which has met with considerable favor in the treatment of large herds of cattle for mange is equally adapted to the application of remedies for ticks, but on account of its expense is not likely to come into general use, and dipping in a vat is therefore on the whole the best and cheapest method of applying remedies when large herds are to be treated.

Farms and pastures may be freed of ticks by treating all cattle at regular intervals with an effective tick-destroying agent. If the treatment is applied with such success as to destroy all ticks that reach the cattle from time to time, thus preventing any engorged females from dropping on the pasture after the beginning of the treatment, the pasture will become free of ticks after the same period of time has elapsed as would have been required if all animals had been excluded, beginning on the same date; that is, a perfectly successful treatment would be practically the same as the complete exclusion of the herd. The dates on which the starving

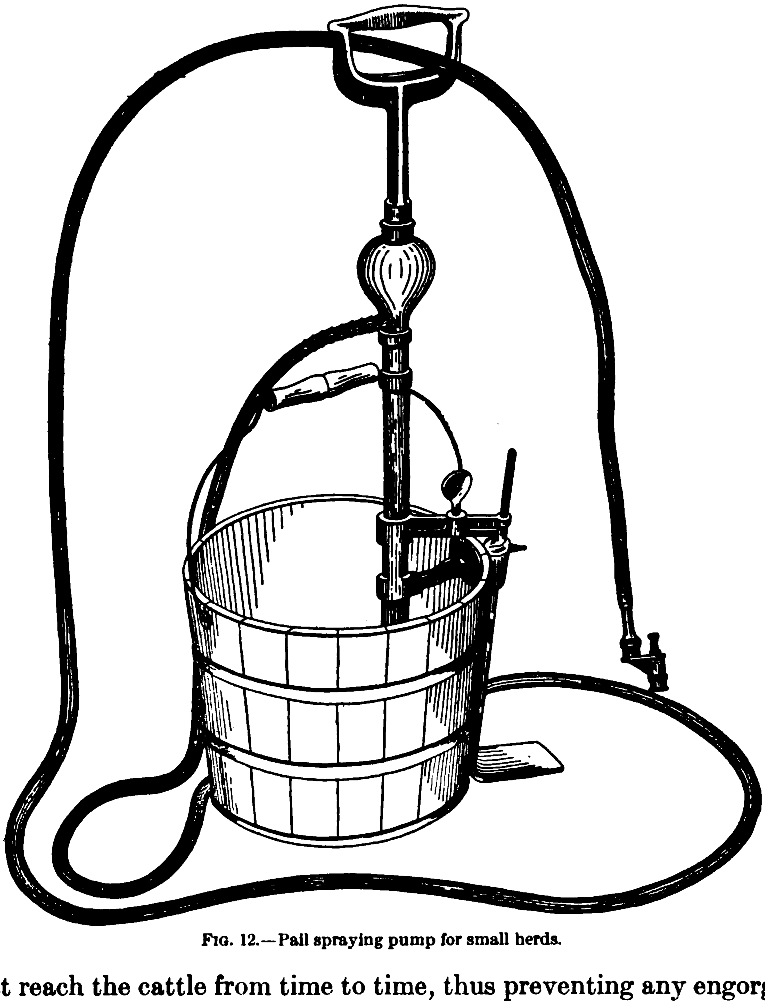

FIG. 12.—Pail spraying pump for small herds.

out of an infestation will be effected when begun at various times of the year have already been given in the table on page 11. In actual practice, however, the best treatment will in many cases not be absolutely successful, as some ticks will escape and may reinfest the pasture and thus prolong the time necessary to accomplish eradication. This method offers the advantage that the pasture may be used continuously.

Dips, their preparation and use.—*Crude petroleum.*—Various kinds of crude petroleum have been used with more or less success in destroying ticks. The heavier varieties of oil are very injurious to cattle. On the other hand, the very light oils are so volatile that their effects last but a short time, thus rendering them less efficient. The petroleum known as Beaumont oil, obtained from Texas wells, has given the best results. The best grade of this oil to use is one that has a specific gravity ranging from 22½° to 24½° Beaumé, containing 1¼ to 1½ per cent of sulphur, and 40 per cent of the bulk of which boils between 200° and 300° C. The oil may be applied by employing a spray pump or a dipping vat.

Animals that have been dipped in crude oil, especially during warm weather, should not be driven any great distance immediately afterwards, and should be provided with shade and an abundance of water. Unless these precautions are observed serious injury and losses may result.

Emulsions of crude petroleum.—In the majority of cases the best agent to use is an emulsion of crude petroleum, preferably Beaumont crude petroleum. The use of the emulsion makes the treatment less expensive than when the oil alone is used. The emulsion is not so injurious to the cattle and is almost if not quite as effective as the oil alone. The formula for preparing an emulsion of crude petroleum is as follows:

Hard soap	pound	1
Soft or freestone water	gallon	1
Beaumont crude petroleum	gallons	4

Making 5 gallons of 80 per cent stock emulsion.

When a greater quantity of stock emulsion is desired, each of the quantities in the above formula should be multiplied by such a number as to furnish the required amount. For example, if it should be convenient to mix 10 gallons at one time, the quantities would have to be multiplied by 2, and if 15 gallons were desired, they would have to be multiplied by 3, and so on.

In preparing the emulsion the soap should be shaved up and placed in a kettle or caldron containing the required amount of water. The water should be brought to a boil and stirred until the soap is entirely dissolved. Enough water should be added to make up for the loss by evaporation during this process. The soap solution and the required amount of oil are then placed in a barrel or some other convenient receptacle and mixed. The mixing may be effected by the use of a spray pump, pumping the mixture through and through the pump until the emulsion is formed. A convenient and time-saving method is to do the mixing in a barrel by first pouring in one part of hot soap solution and then four parts of crude petroleum and repeating this until the barrel is filled. The oil should be poured in with as much force as possible and the mixture stirred constantly with a long paddle until the oil is completely emulsified. The mixing is facilitated also by dipping up the mixture and pouring it back with a pail. If made properly, this stock emulsion is permanent and will keep indefinitely.

To prepare the stock emulsion for use, it is diluted with water to a 20 or 25 per cent emulsion. In order to obtain a 20 per cent emulsion of oil, it is necessary to use one part of the stock emulsion to 3 parts of water, and for a 25 per cent emulsion one part of stock emulsion to 2½ parts of water. The stock emulsion is permanent, but the diluted emulsion does not remain uniformly mixed, so that if allowed to stand it should be thoroughly mixed by stirring before using. Only rain or freestone water should be used for diluting, and if this is not available, the water should be "softened" by adding a sufficient amount of concentrated lye, sal soda, or washing powder. Care should be observed in this process not to use an excess of these preparations.

An 80 per cent stock emulsion is on the market, and much time and labor can be saved by obtaining this instead of making the emulsion. To prepare it for use, it should be diluted in the same manner as indicated above for the homemade stock emulsion.

The arsenical dip.—This dip is used considerably on account of its cheapness and the ease with which it is prepared. In general it has proved very effective in destroying ticks, and is less likely than crude petroleum or emulsions of the same to injure cattle when dipping has to be done in hot weather. Some injury to the skin is, however, likely to occur when the arsenical mixture is used, and this injury, which will be so slight as to be scarcely noticeable if the cattle are properly handled, is liable to be serious if the cattle are driven any distance, especially if allowed to run while being driven within a week after treatment. The formula given below for making an arsenical dip is the one most commonly used in this country:

Sodium carbonate (sal soda)	pounds	24
Arsenic trioxid (white arsenic)	do	8
Pine tar	gallon	1

Sufficient water to make 500 gallons.

If a stronger arsenical dip is desired, 10 pounds of arsenic may be used in place of 8 pounds, but in general the stronger solution should not be used. In warm weather particularly it is not advisable to use a solution stronger than that given in the above formula, if the animals are to be treated every two weeks.

In preparing the dip, a large caldron or galvanized tank is required for heating the water in which to dissolve the chemicals. Thirty or forty gallons of water should be placed in the caldron or tank and brought to a boil. The sodium carbonate is then added and dissolved by stirring. When this is accomplished, the arsenic is added and dissolved in a similar manner. The fire is then drawn and the pine tar added slowly in a thin stream and thoroughly mixed with the dip by constant stirring. This strong stock solution is diluted to 500 gallons before using.

If one desires, double or triple the amount of stock solution indicated above may be prepared at one time, provided a large enough vessel is available. In case a small vessel holding 20 to 25 gallons must be used, half of the stock solution indicated may be prepared. This will, however, consume so much more time in preparing large quantities that when possible it is advisable to provide a large vessel for dissolving the chemicals.

The stock solution, if it is to be used for dipping, may be placed in the vat as fast as it is prepared, or, if it is to be used for spraying, may be stored in barrels. The most convenient way of diluting the dip is to run the water into the vat through a hose or pipe. The capacity of the vat, if not known, should be calculated, and for convenience the water line marked at several places on the sides. After the exact amount of stock solution necessary to furnish diluted dip to fill the vat has been prepared and placed in the vat, all that is necessary is to allow water to flow into the vat until the surface of the dip reaches the marks made on the sides of the vat. For example, if the capacity of the vat is 2,000 gallons, then four times the amount of the stock solution necessary to make 500 gallons of the dip should be prepared, placed in the vat, and the latter filled with water to the 2,000-gallon mark.

When for any reason it is not convenient to follow the above method of diluting the dip, a stock solution may be prepared in which the quantity of ingredients for 500 gallons of diluted dip are dissolved in 50 gallons of water. Nine parts of water to one part of this stock solution will then give the proper dilution. This stock solution is found very convenient when small amounts of diluted dip are required from time to time for spraying cattle. Fifty gallons of the stock solution can be placed in a barrel and just the amount required each time taken out and diluted.

The diluted arsenical solution may be left in the vat and used repeatedly, replenishing with the proper quantities of water and stock solution when necessary. When not in use the vat should be tightly covered with a waterproof cover to prevent evaporation on the one hand and further dilution by rain on the other hand. Securely covering the vat when not in use also lessens the risk of accidental poisoning of stock and human beings.

Precautions in use of arsenic.—**On account of the fact that arsenic is a dangerous poison, great care must be observed in making and using the arsenical dip. From the time the arsenic is procured from the druggist until the last particle of unused residue is properly disposed of, the most scrupulous care should be taken in handling this poison. Guessing at weights or measures or carelessness in any particular is liable to result in great damage, and not only may valuable live stock be destroyed, but human beings may lose their lives as well.**

In the use of arsenical dips care should be taken not only to avoid swallowing any of the dip, but persons using the dip should also bear in mind the possibility of absorbing arsenic through cuts, scratches, or abrasions of the skin, and the possibility of absorbing arsenic by inhalation of vapors from the boiler in which the dip is prepared, or by the inhalation of the finely divided spray when the spray pump is used. It should be remembered that the absorption of even very small quantities of arsenic if repeated from day to day is liable ultimately to result in arsenical poisoning.

Cattle should always be watered a short time before they are dipped. After they emerge from the vat they should be kept on a draining floor until the dip ceases to run from their bodies; then they should be placed in a yard free of vegetation until they are entirely dry. If cattle are allowed to drain in places where pools of dip collect, from which they may drink, or are turned at once on the pasture, where the dip will run from their bodies on the grass and other vegetation, serious losses are liable to result. Crowding the animals before they are dry should also be avoided, and they should not be driven any considerable distance within a week after dipping, especially in hot weather. If many repeated treatments are given the cattle should not be treated oftener than every two weeks.

In addition to properly protecting vats containing arsenical dip when not in use, another precaution must be observed when vats are to be emptied for cleaning. The dip should not be poured or allowed to flow on land and vegetation to which cattle or other animals have access. The best plan is to run the dip in a pit properly protected by fences. The dip should also not be deposited where it may be carried by seepage into wells or springs which supply water used on the farm. The same precautions should be observed when animals are sprayed as when they are dipped.

Method of spraying.—Spraying is probably the most practicable and convenient way of treating cattle on the majority of farms. A good type of pail spray pump (fig. 12), costing from $5 to $7, will be found satisfactory for treating small herds. About 15 feet of ⅜-inch high-pressure hose is required, and a type of nozzle furnishing a cone-shaped spray of not too wide an angle will be found satisfactory. A nozzle with a very small aperture should not be used, because the spray produced is too fine to saturate properly the hair and skin of the animals without consuming an unnecessary amount of time.

The animal to be sprayed should be securely tied to one of the posts of a board or rail fence, or, better still, when convenient, to the corner post in an angle of the fence. This will facilitate the spraying by preventing the animal from circling about to avoid the treatment, and will reduce the amount of help necessary. Every portion of the body should be thoroughly treated, special attention being given to the head, dewlap, brisket, inside of elbows, inside of thighs and flanks, the tail, and the depressions at the base of the tail. Crude oil alone may be used, but in general a 20 to 25 per cent emulsion will be found more satisfactory.

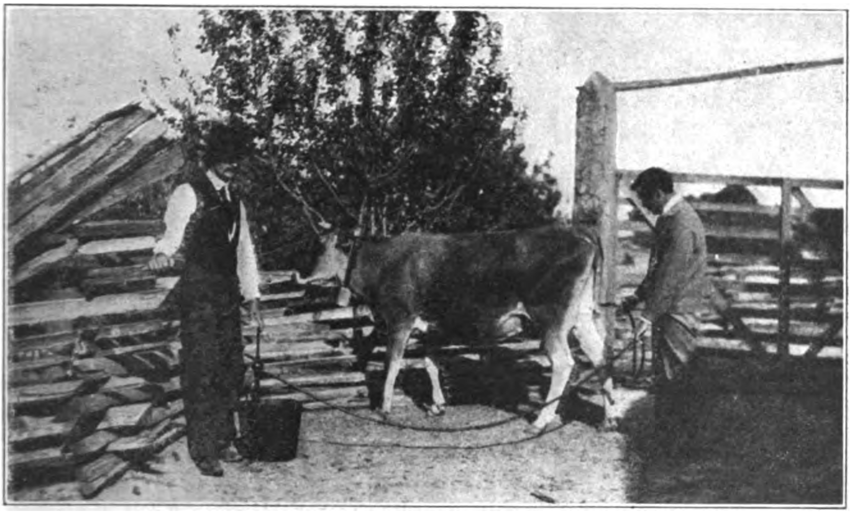

FIG. 13.—Spraying cow from pail with hand pump.

All the cattle on the place should be sprayed every two weeks with this emulsion. The horses and mules should be kept free of ticks by picking or other means. If on account of heavy rains or other causes the oil disappears rather rapidly from the skin of the cattle, spraying should be carried out oftener. The interval should never be greater than two weeks, and spraying should not be discontinued simply because the ticks have become scarce or seem to have disappeared. This is a great temptation to the busy farmer, on account of the labor and expense incident to spraying, but in the long run it is shortsighted economy, since in most cases it will increase the time necessary for eradication. If the ticks have entirely disappeared from the cattle during the fall and winter, this does not necessarily mean that eradication has been accomplished, because there may be present on the premises dormant seed ticks, live females, and eggs that will hatch with the coming of warm weather. It can not be determined until the next summer whether eradication has been entirely accomplished.

In localities where ticks commonly occur on cattle in considerable numbers during the winter time it will be advisable to continue spraying. In localities where ticks disappear or are present in very small numbers during the winter, the cattle should be inspected carefully each week to remove and destroy any ticks that may be present. When warm weather comes, it will be well in all cases in which spraying has been discontinued during the winter to begin spraying and continue until it can be determined with certainty that eradication has been accomplished. The spraying should not be delayed until ticks show again in considerable numbers. One tick destroyed in the early spring will save the trouble of destroying thousands a few months later.

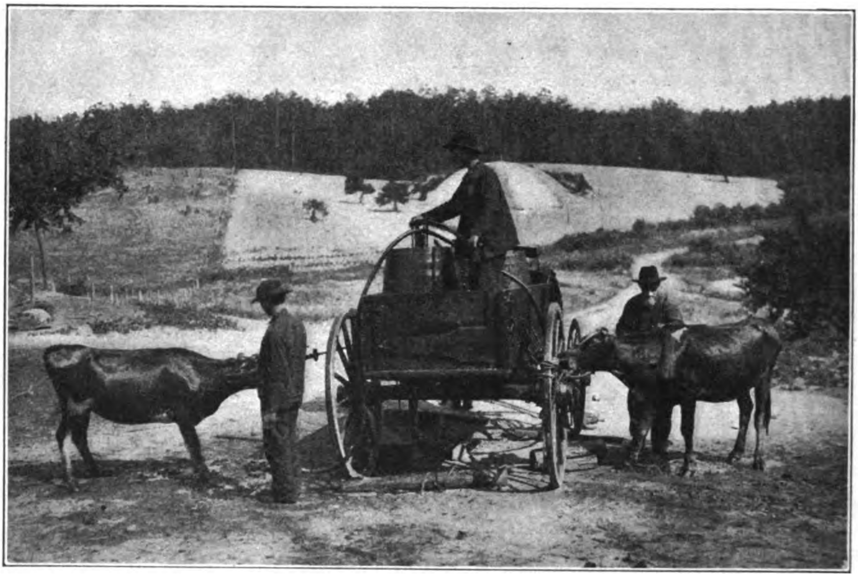

FIG. 14.—Spraying cattle with hand pump from barrels on wagon.

At the time of the first spraying all the large ticks should be removed by hand and destroyed. This will also be a very helpful thing to do at each spraying, when it is possible, because large females are likely to drop in a few hours after the cattle have been treated, and consequently may not suffer a great deal from the oil. The farmer who has a small herd which is handled every day should be constantly on the lookout for large ticks. A few minutes spent each day in removing and destroying these ticks will materially aid any treatment employed to eradicate the tick. Eradication will also be much facilitated if at the beginning of the work all litter and manure are removed from stables, sheds, and yards that have been occupied by the cattle, and deposited on land where cattle are not permitted to run. After this is done the buildings should be thoroughly disinfected to destroy any eggs or ticks that may be there. For this purpose the following substances may be used:

1. A mixture made with not more than 1½ pounds of lime and one-fourth pound of pure carbolic acid to each gallon of water.
2. Any coal-tar creosote dip permitted by the United States Department of Agriculture in the official dipping of sheep for scabies, diluted to one-fifth of the maximum dilution specified for dipping sheep.

A spray pump should be used to apply the disinfectant, and the walls, floors, and various fixtures of the buildings should be thoroughly sprayed.

Specifications and materials for a dipping vat.—A vat constructed according to the accompanying plans will hold 2,088 gallons when filled to a depth of 5 feet.

Excavation.—Excavate for the vat, as shown by the drawings (fig. 15), to the proper depth. Level the bottom of the pit for the sills. After the vat is completed fill in around it, using the surplus earth to bring the grade at the sides of the vat a little above the natural grade and slope the surface away from the vat. Dig the holes required for all posts, etc.

Carpenter work.—The drawings show the vat constructed according to two methods. One method is to make the sides of 4 by 4 inch posts spaced about 3 feet apart and lined with 2 by 8 inch dressed, sized, and bevel-edged plank, using 20-penny spikes to fasten them to the posts and braces. All the joints are to be calked with oakum well driven in with a calking iron and pitched. The floor of the vat and the inclines are to be made of 2-inch plank with joints calked, the exit incline to have 2 by 4 inch cleats spiked to the plank flooring. The slide should have an angle of about 25° and should be covered with No. 16 galvanized iron.

The other method is to build the sides of the vat of 2 by 4 inch posts and 2 by 4 inch braces spaced about 16 inches on centers. The 2 by 4 inch posts and braces are to be lined with ⅞ by 8 inch tongued-and-grooved flooring, blind nailed at every bearing with 10-penny nails. All the joints are to be laid in white lead paste and the boards firmly driven up.

Lumber.—The lumber used in the construction of the vat must be thoroughly dried and seasoned stock, free from large and loose knots, straight grained, and free from sap.

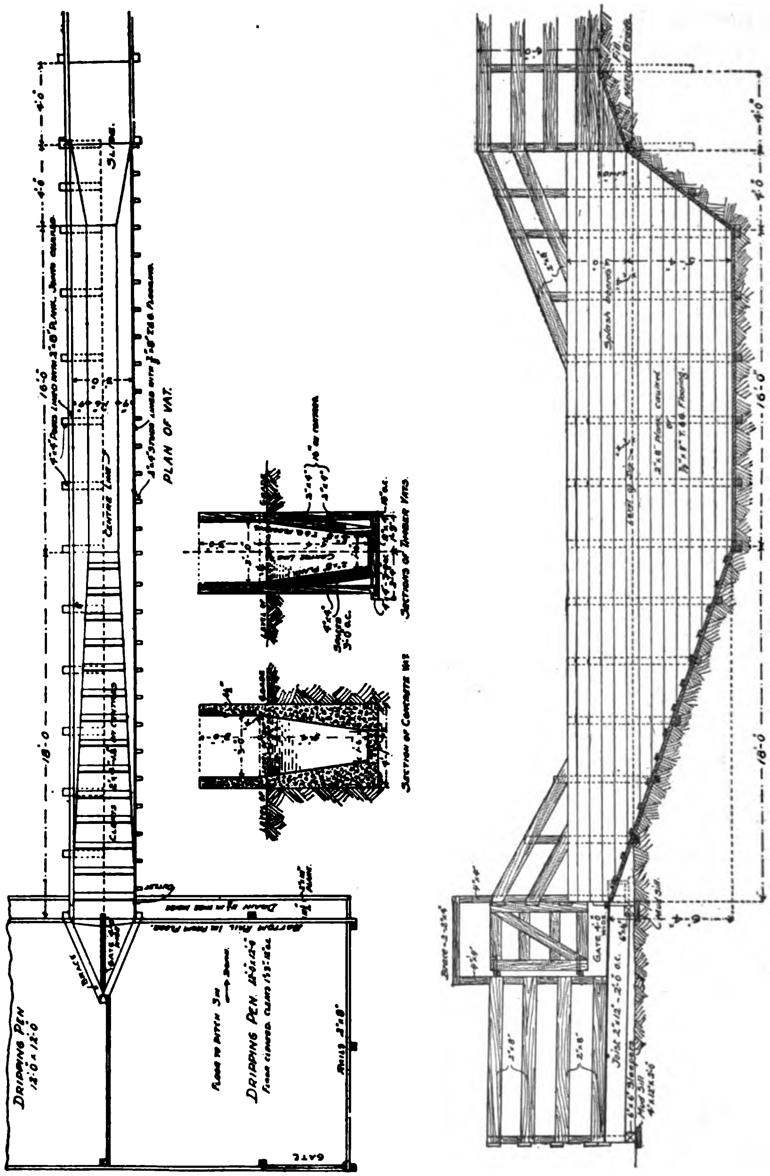

FIG. 15.—Drawings for wood or concrete dipping vat.

Gutters.—The gutters for the dripping pens should be made of sound stock, the bottom plank housed into the sides and ends, and the ends housed into the sides. All the joints are to be laid in white lead paste and thoroughly nailed. Gutters are to have 3-inch fall in 11 feet.

Concrete vat.—The concrete vat should be made of concrete composed of 1 part by measure of good Portland cement, 3 parts of clean sharp sand, and 5 parts of broken rock, the broken rock to be not larger than will pass in any direction through a 2-inch ring. The rock should be washed free of dust. Concrete should be mixed wet and well tamped into place.

Bill of materials for vat and draining pens.—*Vat.*—Lumber for vat when constructed of 2-inch material and 4 by 4 inch posts:

Sills	8 pieces 4 by 4 inches by 10 feet long.
Posts	1 piece 4 by 4 inches by 16 feet long.
	1 piece 4 by 4 inches by 14 feet long.
	6 pieces 4 by 4 inches by 12 feet long.
	5 pieces 4 by 4 inches by 10 feet long.
Braces	1 piece 4 by 4 inches by 16 feet long.
	6 pieces 4 by 4 inches by 12 feet long.
	1 piece 4 by 4 inches by 10 feet long.
	1 piece 4 by 4 inches by 6 feet long.
Guards	2 pieces 2 by 8 inches by 18 feet long.
	1 piece 2 by 8 inches by 16 feet long.
	2 pieces 2 by 8 inches by 12 feet long.
	1 piece 2 by 8 inches by 10 feet long.
Sides	18 pieces 2 by 8 inches by 20 feet long.
	25 pieces 2 by 8 inches by 18 feet long.
	2 pieces 2 by 8 inches by 16 feet long.
	2 pieces 2 by 6 inches by 18 feet long.
	Dressed one side and two edges.
	Edges bevelled for calking.
Floor	3 pieces 2 by 10 inches by 20 feet long.
	2 pieces 2 by 10 inches by 16 feet long.
	1 piece 2 by 10 inches by 14 feet long.
	1 piece 2 by 10 inches by 7 feet long.
	1 piece 2 by 12 inches by 12 feet long.
	Dressed one side and two edges.
	Edges bevelled for calking.
Cleats	4 pieces 2 by 4 inches by 12 feet long.

Lumber for vat when constructed of flooring and 2 by 4 inch posts:

Sills	7 pieces 2 by 4 inches by 14 feet long.
Posts	28 pieces 2 by 4 inches by 18 feet long.
	4 pieces 4 by 4 inches by 11 feet long.
Braces	15 pieces 2 by 4 inches by 12 feet long.
	2 pieces 2 by 4 inches by 10 feet long.
	2 pieces 2 by 4 inches by 16 feet long.
Guards	Materials the same as specified above.
Sides	550 feet b. m. 7/8 by 8 inches tongue and grove flooring.
Floor	Materials the same as specified above.
Cleats	Materials the same as specified above.

Lumber for draining pens:

Mud sills	10 pieces 4 by 12 inches by 2 feet long (cedar or cypress).
Sleepers	4 pieces 6 by 6 inches by 12 feet long.
Joists	13 pieces 2 by 12 inches by 12 feet long.
Floor	360 feet b. m. tongue and grove flooring ⅞ by 8 inches—12-foot pieces.
Cleats	265 linear feet 1 by 3 inches.
Gutters	Sides: 4 pieces 2 by 12 inches by 11 feet long (dressed). Bottom and ends: 2 pieces 2 by 12 inches by 12 feet (dressed). Bottom housed into sides and ends. Ends housed into sides. All joints calked and white leaded or pitched.
Posts	11 pieces 4 by 4 inches by 7 feet long. 2 pieces 4 by 4 inches by 8 feet long. 2 pieces 4 by 4 inches by 9 feet long.
Rails	2 pieces 2 by 8 inches by 18 feet long. 5 pieces 2 by 8 inches by 16 feet long. 18 pieces 2 by 8 inches by 12 feet long.
Braces	2 pieces 2 by 4 inches by 10 feet long.
Gates	7 pieces 1 by 6 inches by 12 feet long. 6 pieces 1 by 6 inches by 10 feet long.

Hardware for vat and draining pens:

4 pairs 12-inch heavy T hinges and screws.
4 wrought-iron hooks and staples.
1 pair wrought-iron hook hinges, 12-inch, wood screw hooks, and screws.
50 pounds 20-penny wire nails.
15 pounds 10-penny wire nails.
12 square feet No. 16 galvanized iron.

When vat is constructed of flooring and 2 by 4 posts, the following additional hardware will be required:

19 pounds 20-penny wire nails.
12 pounds 10-penny wire nails.

Material for concrete vat:

Concrete, 1 part Portland cement, 3 parts sand, 5 parts broken rock or gravel.
19 cubic yards broken rock or gravel.
18 cubic yards sand.
30 barrels Portland cement.

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress**, or to the Secretary of Agriculture, Washington, D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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Issued November 27, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 379.

HOG CHOLERA.

BY

M. DORSET, M. D.,

Chief of the Biochemic Division, Bureau of Animal Industry.

WASHINGTON:
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1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., September 15, 1909.

SIR: I have the honor to transmit for publication as a Farmers' Bulletin an article on "Hog Cholera," by Dr. M. Dorset, chief of the Biochemic Division of this Bureau. This paper is intended to supersede Farmers' Bulletin 24, "Hog Cholera and Swine Plague," published ten years ago, it having become desirable to replace that bulletin with one embodying the knowledge gained from the laboratory and field experiments which have in the meantime been carried on by the Biochemic Division.

The highly important discoveries concerning the cause and prevention of hog cholera have been more fully set forth from time to time in the publications of this Bureau. It is now well known that our laboratory experiments proved conclusively that the so-called hog-cholera bacillus was not the primary cause of the disease, this being attributed to an invisible (ultramicroscopic) organism. Having disposed of this point, it became our aim to devise some means of preventing the spread of the scourge, and for several years our efforts have been directed to the production of a serum that could be relied upon to immunize susceptible hogs, and this has now been successfully accomplished. Extensive field experiments have shown that the Bureau's preventive serum is definitely successful in combating hog cholera, under practical farm conditions. This result naturally created a large demand for the serum, so an attempt was made to interest the State authorities, particularly those in the hog-raising sections, with a view to having each State supply its farmers with reliable serum at a reasonable cost. The Secretary of Agriculture extended invitations to all the States to send representatives to the Bureau's experimental farm near Ames, Iowa, for conference on this subject, and more than twenty-five States were represented at three meetings held, respectively, in May, July, and October, 1908. Evidence of the efficacy of the serum was presented to the State representatives and the technique of preparing the serum was demonstrated. It is gratifying to report that several State institutions are now engaged in the manufacture and distribution of the serum.

Doctor Dorset has prepared this bulletin especially for the use of the practical farmer, in order that he may be enabled to recognize the disease and to deal with it effectively.

Respectfully,
A. D. MELVIN,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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HOG CHOLERA.

INTRODUCTION.

Hog cholera is an acute febrile disease which, so far as is known, affects only hogs, and which is characterized by extreme contagiousness and a very high death rate. It is usual to speak of two forms of this disease. One is called the acute and the other the chronic form. This is because of the fact that in some cases the disease is sudden in its onset and rapid in its course, whereas in others the affected hogs linger for weeks or months before death or recovery. Notwithstanding the dissimilarity in the symptoms and lesions observed in these two types of hog cholera, the causative agent is the same in both, the difference in the manifestations of the disease being no doubt due to a variation in the virulence of the germs which cause the disease, and possibly to some extent also to a variation in the resisting power of hogs.

Hog cholera is found in practically all parts of the world, and is especially prevalent in the large hog-raising districts of the United States. The first recorded outbreak in this country occurred in the year 1833 in the State of Ohio, and is supposed to have arisen through the importation of hogs from European countries, where the disease, no doubt, existed prior to its appearance in this country. From the original center of infection the disease has gradually extended to all portions of the United States, the spread being usually along the lines of transportation. Owing to the former limited facilities for communication between the Eastern and the Pacific Coast States, the latter section remained free of this disease until within the last few years, but reports received recently show that the disease now exists there, and at the present time no section of the United States may be regarded as free from hog cholera. Enormous losses are caused yearly in the large hog-raising States of the Middle West, and it may be safely said that several of these States lose yearly an average of more than $1,000,000 each from this source alone. While outbreaks may occur at all seasons of the year, the great majority take place during the late summer and fall. The mortality from hog cholera is as high as 100 per cent in some herds, while the average is probably from 70 to 80 per cent, and many of the hogs which survive are comparatively worthless, owing to their being weakened and stunted in growth.

CAUSE OF THE DISEASE.

THE GERM WHICH CAUSES HOG CHOLERA.

The germ or microbe which causes hog cholera is present in the blood of sick hogs and also in the excretions from such hogs, particularly in the urine. It has been shown that the disease can be produced almost without fail by inoculating well hogs with the blood or urine from sick hogs. The germ which is in this blood and urine is so small, or else of such structure, that it can not be seen with the strongest microscopes now available. It has never been cultivated in laboratories, as has been done with many other infectious germs, and we know of it only by the effects which it produces. The germ of hog cholera is therefore classed with the "invisible micro-organisms," and in this respect it resembles those which bring about a number of other diseases of animals and men, notably yellow fever, contagious pleuro-pneumonia, South African horse sickness, and foot-and-mouth disease.

PREDISPOSING CAUSES.

While the specific cause of hog cholera is the minute microorganism or germ just referred to, there are many factors which may render a herd more susceptible to the disease. In general, anything which tends to lower the health of the animals may be regarded as a predisposing cause. Among such predisposing factors there may be mentioned improper feeding, an insanitary condition of the hog lots, damp or cold sleeping places, and dirty drinking and feeding troughs. Of course insanitary surroundings and poor feed can not in themselves produce hog cholera, but they lower the vitality of hogs to such an extent that they become comparatively easy victims of any disease-producing germs to which they are exposed.

WAYS IN WHICH THE HOG-CHOLERA GERM REACHES A HERD.

Although the conditions just mentioned undoubtedly exert considerable influence upon the relative resisting powers of hogs to hog cholera, the disease can be started in a herd only by introducing the germ which causes it. This germ is always present in the bodies of sick hogs, and is thrown off from them in large numbers in the feces and urine, thus contaminating the yards or pens in which sick hogs are kept. The most dangerous factor in spreading hog cholera is, therefore, the sick hog; but any agency which might serve to carry a particle of dirt from infected yards may be the means of starting an outbreak of the disease.

Sick hogs may get onto a farm (1) by escaping from a neighboring herd, (2) by the purchase of new stock which may show no symptoms of sickness until some days after purchase, (3) by returning show hogs to the herd after visits to fairs or stock shows, (4) by purchase of hogs which have apparently recovered from hog cholera. The risk incurred by purchase of new hogs or the return of hogs which have been shown at fairs is chiefly due to the fact that such hogs are generally transported by rail, unloaded in public stock yards, or driven along public roads. It is well known that sick hogs are frequently shipped by rail, and the roads over which they are driven, the stock yards, and the railroad cars thus become contaminated with the germs of hog cholera. When healthy hogs are placed in such cars or yards or driven along public roads they almost always have the opportunity to contract the disease, but the interval between shipment and delivery to the purchaser is so short that the symptoms do not appear until a week or more after delivery, when it is usually too late to prevent the spread of disease to hogs already on the farm. Obviously, the only safe plan in such cases is to place all new arrivals in lots entirely separated from those occupied by the main herd and to keep them isolated until all danger of their developing hog cholera has passed.

Aside from the danger of introducing infection through the hogs themselves it must be remembered that the germ of the disease, which as already stated is infinitesimally small, may be transported in a minute particle of dirt on the feet of attendants or neighbors who have previously visited farms where hog cholera exists. It may also be carried in this way by dogs, and by crows and other birds. It has been claimed, and considerable proof has been brought to show it, that the disease may be carried downstream from herds which are affected above. It is therefore well to avoid placing hogs so that they will have access to streams which pass through other farms. As diseased hogs are frequently transported by rail, it is quite possible for infection to be introduced into a farm by litter dropped from cars in transit, especially if hogs on the farm have access to the tracks.

After hog cholera has visited a farm, the lots, hog houses, feeding troughs, and implements used for cleaning have naturally become contaminated with the germs of the disease, and if new stock is placed in such yards soon after these were occupied by sick hogs the new hogs are very likely to contract the disease, but if such yards are left unoccupied the germs will die out after a while. Unfortunately it is not possible to tell with certainty just how long a time is required for these germs to die out, this uncertainty being due to the fact that conditions on different farms vary widely, and also because the weather conditions, which have an important influence upon the vitality of the hog-cholera germ, vary from time to time and in different sections of the country. In view of this uncertainty it is safest to wait as long as possible before placing new hogs in lots that have been infected. Such premises should not be restocked sooner than three months after the last hog has been removed. Before restocking, the premises should be cleaned and thoroughly disinfected in the manner described under the heading "General preventive measures."

SYMPTOMS OF HOG CHOLERA.

The beginning of hog cholera in a herd is marked by the sickness of one or two hogs. There is nothing particularly characteristic in the symptoms displayed, and the presence of the disease may not be suspected until a week or two later, when other hogs are attacked. As the number of sick hogs increases the opportunities for the well animals to contract the disease are multiplied, and in a comparatively short time all hogs exposed to the contagion will be attacked.

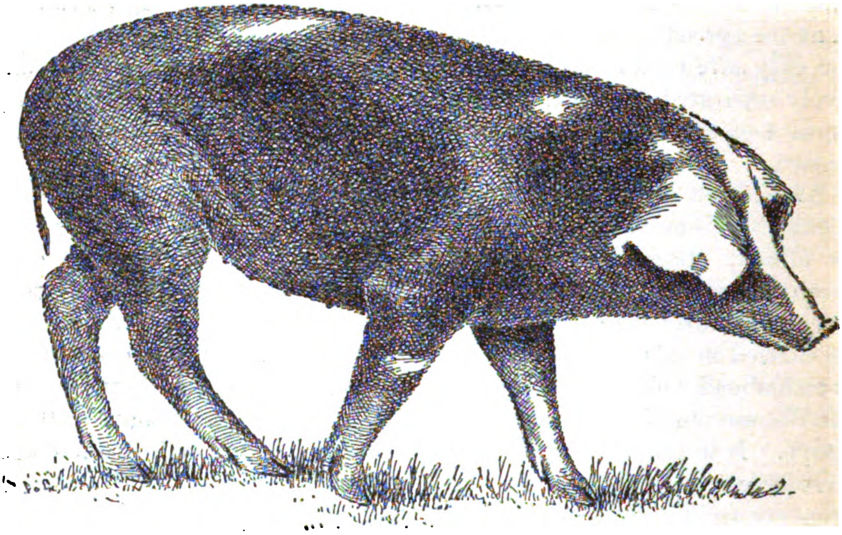

FIG. 1.—Hog sick of hog cholera (chronic type).

The symptoms observed in particular cases will be influenced by the virulence of the germ which is responsible for the attack, and also by the resisting power of the hogs in the herd. If this resisting power is low, or if the germ which is the cause of a particular outbreak is of high virulence, we may have in such a herd a typical manifestation of the acute type of hog cholera. In this acute type, the chief symptoms observed are sluggishness, disinclination to move, weakness, loss of appetite, a high fever, inflammation of the eyes with gumming of the lids, and there may be diarrhea. If the sick animals are examined carefully, red or purplish blotches may be seen on the skin, especially over the surface of the abdomen, on the inside of the legs, and around the ears and neck. As a rule the progress of the infection is so rapid that the hog is not greatly emaciated before death; it is, in fact, usual in acute outbreaks for hogs to die after being sick only a few days.

In the chronic type of the disease the symptoms are quite similar to those seen in acute cases. The sick hogs are sluggish and disinclined to move when disturbed, and coughing is frequently heard when they are suddenly roused. They may eat very little and usually lose flesh rapidly, finally becoming so emaciated and weak that they stagger or walk with an uncertain gait, the hind legs particularly appearing to be very weak. (Fig. 1.) The eyes become inflamed and the lids may be gummed together. After the first few days of illness there is apt to be a profuse diarrhea, and in these chronic cases the hog may, and usually does, linger for several weeks, sometimes months, before it finally dies. It is extremely rare for such an animal to recover its health and vigor sufficiently to become of value to the owner.

It will thus be seen that before death the appearance of hogs affected with hog cholera is not particularly characteristic, for the symptoms, especially in acute cases, are only such as might be expected in a severe disease of any kind. But if these symptoms are noticed in a herd of hogs, and if the disease is seen to be contagious, showing a tendency to spread from the sick to the healthy animals, it is likely that hog cholera is present, though in order to be sure of this a post-mortem examination must be made.

APPEARANCE OF A HOG AFTER DEATH FROM HOG CHOLERA.

In regard to the examination of hog carcasses on the farm, it may be well to state that while hog cholera is not communicable to man, there is always danger of the hog being infected with other diseases, such as tuberculosis and anthrax, which are highly dangerous to man, and for this reason care should be exercised in examining carcasses of sick hogs so as to avoid a cut or scratch on the hands which might serve as a point for the inoculation of disease.

The post-mortem examination of a hog should begin with the skin, which may show the red or purplish blotches which have been mentioned above as one of the symptoms of hog cholera. When the examination of the skin has been made, the organs of the body are examined in the following manner: The hog is laid on its back, and, beginning at the throat, an incision is made along the middle of the chest and belly, through the skin and underlying fat, and extending the entire length of the body. The next step is to dissect back the skin of the chest so that the ribs are exposed. Now, beginning at the lower border of the ribs, about 1 or 2 inches on either side of the breast bone, and cutting toward the head, the ribs on both sides are severed, the central portion, including the breast bone, being removed entirely. Crosswise incisions, extending from the first long incision toward each leg, are now made in the skin in such a manner that this may be laid back on both sides of the body, thus exposing to view the various organs which lie in the chest and abdominal cavities (see fig. 2).

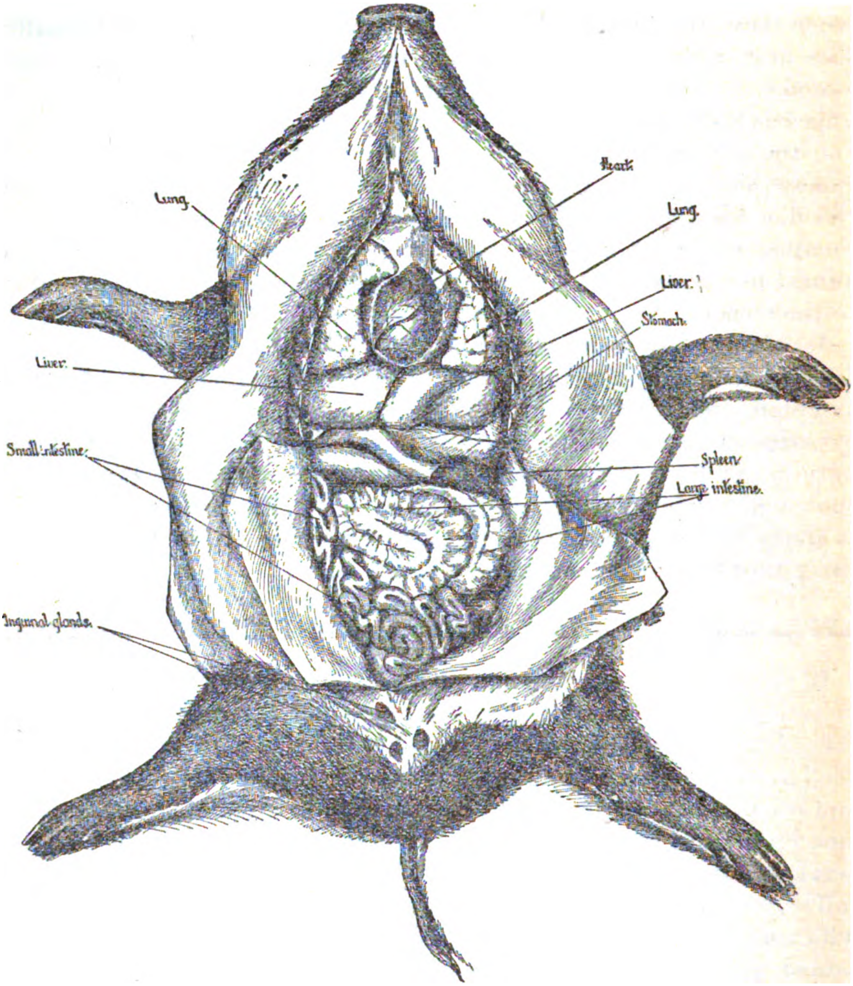

FIG. 2.—Showing location of organs which may be affected by hog cholera.

While the carcass is being opened, care should be taken to avoid injuring the organs. The important organs are examined as follows:

Lungs.—The healthy lungs are pink in color, soft, and filled with air. Occasionally, in that portion of the lungs nearest the neck, small, solid, dark areas may be seen in healthy hogs. Such areas without other lesions are not to be regarded as indicating hog cholera. In acute cases of hog cholera the surfaces of the lungs frequently show numbers of small red spots of varying size which are caused by the rupture of minute blood vessels, thus allowing the blood to escape into the tissue. These spots can not be washed off with water and when found are an important indication of hog cholera. It is not unusual to find that large portions of the lungs are consolidated, and instead of being soft, filled with air, and pink in color, as is the case in normal lungs, the organs are heavy, solid, and of a grayish or dark-red color. This consolidation of the lungs is not so characteristic of hog cholera as the reddish spots mentioned above.

Heart.—The heart is inclosed in a thin membranous sac which can be easily slit open and removed so as to permit a satisfactory examination of the organ. In cases of hog cholera, the surface of the heart may show bloody-looking blotches similar to those seen in the lungs and which, like those in the lungs, can not be washed off with water. These bloody spots on the heart are rarely seen except in very acute and virulent forms of hog cholera.

Liver.—In cases of hog cholera the liver generally shows no marked change from the normal condition. It may be at times darker than normal in color, and if cut with a knife blood will exude. This indicates simply that the organ is congested. In some cases the liver may be of a light-grayish color, due to the increase of fibrous substances. Neither of these conditions is especially characteristic of hog cholera.

Spleen.—The spleen, or melt, which is found on the right-hand side of the hog's body as viewed at autopsy, lying a little below and to the right of the stomach, is in acute cases of hog cholera found almost without exception to be quite large, dark, and soft. In the prolonged, chronic cases, however, the spleen may be even smaller than normal and rather grayish in color.

Kidneys.—The kidneys, which lie beneath the intestines as viewed at autopsy, can be easily removed by pulling aside the soft fat and tissues which surround them and cutting the round tube which holds them to the body. The thin fibrous tissue which surrounds the kidneys should be carefully peeled off without cutting into or injuring the organ, and if the case is one of acute hog cholera, it is very likely that the normal light-brown color of the kidneys will be found to be changed to a much darker color, and there may be seen over the surface a number of very dark-red points, some of these no larger than a pin point, whereas others may be larger than the head of a pin. The appearance of the kidneys frequently reminds one of the speckling of a turkey's egg. These spots are caused by the escape of blood from the small blood vessels in the same way as the larger reddish spots which occur in the lungs and on the heart. Both kidneys should be examined.

Stomach.—The stomach is the large white pouch-like organ which is situated in the upper part of the abdominal cavity next to the lungs and by the side of and partly underneath the liver. Usually the external surface of the stomach shows no change from normal, though occasionally there may be observed small red spots similar to those which have been described as appearing in the lungs, heart, and kidneys. The stomach should be opened by cutting the front wall from one end to the other. The partly digested food which is usually found within the stomach is removed and water poured in so as to clean the inner surface and permit a satisfactory examination. The normal stomach lining is a uniform, rather wrinkled, pinkish-looking membrane. It is smooth and free from distinct hemorrhages. In cases of hog cholera it is not infrequent to find large portions of this lining membrane of the stomach very much inflamed and red, and a careful examination will frequently show that this lining membrane has been ulcerated. The ulcerated portion usually extends over a considerable area of the lining membrane of the stomach and is separated from the healthy portion by a more or less distinct line.

Small intestine.—The intestines are connected directly to the stomach. The small intestine is that portion which begins at the stomach and continues until a distinct union is made with a portion of the large intestine known as the cecum or blind gut. In normal hogs both the outer and inner surfaces of the small intestine resemble considerably those of the stomach, though of course the walls of the intestine are not nearly so thick. The small intestine is well supplied with small blood vessels which can be distinctly seen. In some acute and virulent types of hog cholera the outer surface of the small intestine may be literally covered with bloody spots, giving one the impression that blood had been spattered over these organs, but upon washing them with water it will be found that these bloody areas can not be removed. There is no other characteristic lesion of the outer surface of the small intestine. The inner lining, however, may at times, in cases of hog cholera, be congested and inflamed, so that the normal wrinkled inner surface is greatly thickened and covered with a yellowish exudate or coating, or it may be dotted with small bloody spots like those seen on the outer surface of the intestine.

Large intestine.—The large intestine differs markedly from the small intestine in general appearance, being larger in circumference and of more uneven surface. The appearance of the large and small intestines in health and their relative positions in the body are shown in figure 2. In cases of hog cholera the outer surface of the large intestine may show the same hemorrhagic spots that have been mentioned as occurring on the small intestine, but it is the inner lining that shows the most important changes.

In acute cases of hog cholera the inner lining of the large intestine is frequently found to be blood stained and small areas of a bloody extravasation are seen. It is also frequently found that the feces contained in the large intestine are bloody, due to blood having escaped from the bleeding portion of the intestine. In the case of hogs which do not die quickly from the disease—that is, in chronic cases—we are

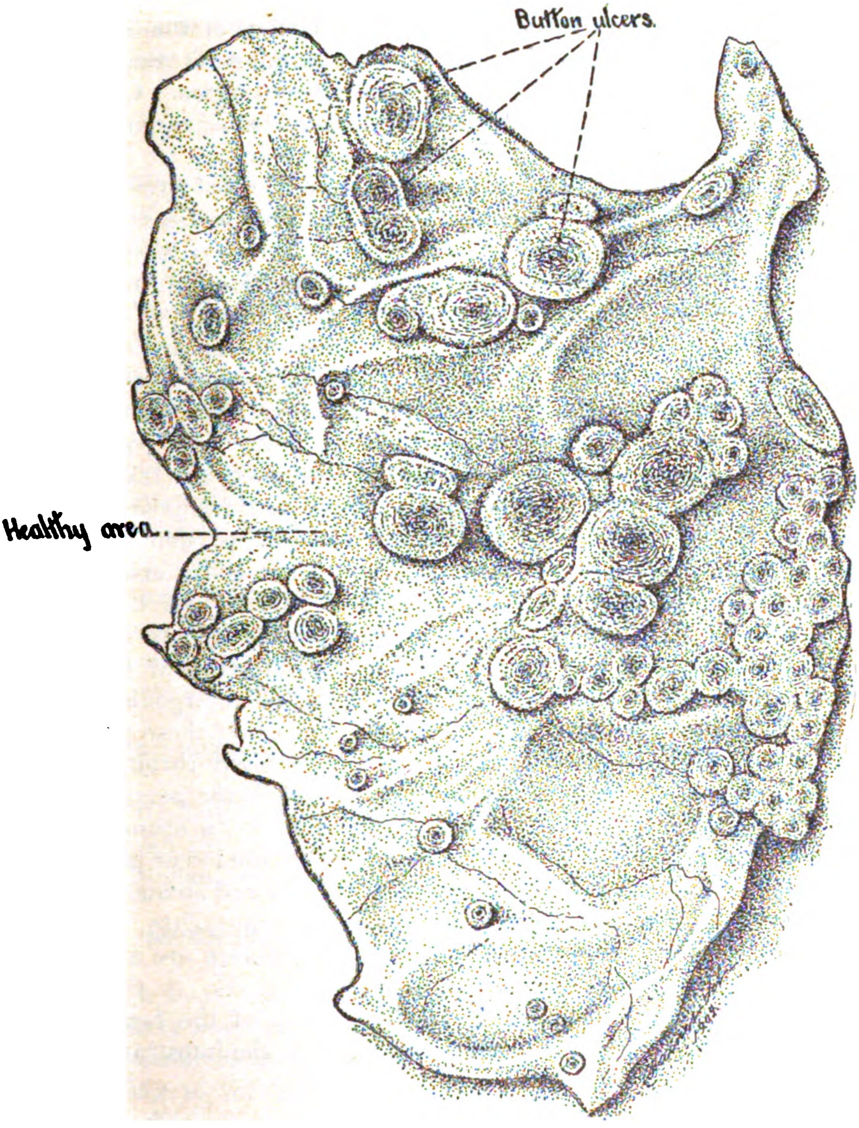

Fig. 3.—Portion of large intestine of hog, showing button-like ulcers caused by cholera.

apt to find on the inner surface of the large intestine what are generally regarded as the most characteristic lesions of hog cholera. These are the so-called "button" ulcers. These ulcers are usually round, hard, and yellowish, with a dark center, and are distinctly raised above the surrounding healthy inner surface of the large intestine. They vary greatly in size, some being very small points, whereas others are larger than a silver 25-cent piece. Once these lesions have been seen, they can not be mistaken afterwards. A very good idea of their appearance is given in figure 3.

The finding of the typical button ulcer may be considered as a positive indication of hog cholera, and it is the only lesion that can be regarded as absolutely diagnostic, though the bloody points or hemorrhages in the kidneys, heart, and other organs of hogs are rarely seen in diseases other than hog cholera in the United States.

Lymphatic glands.—Aside from the lesions of the various organs which have been described, the changes which take place in the lymphatic glands of a hog that has died from hog cholera are of much importance. These glands are found in different parts of the body. The most important ones to be examined are those in the inguinal region; these will be readily found and recognized by the farmer. These glands are situated in the fat just under the skin of the abdomen, near the median line of the body, and between the hind legs (see fig. 2). These glands, if normal, will be found to be of a rather light-grayish color. After normal glands have been seen, the changes which occur in cases of hog cholera will be readily recognized. These changes consist chiefly in an enlargement of the glands together with a marked reddening. At times these glands are so red as to appear almost black, and if they are cut through with a knife it will be found that the exterior or rind is the portion chiefly affected. Other lymphatic glands which undergo a change of this kind in hog cholera are found at the angles of the lower jaw, in the neighborhood of the heart, and beneath the liver and stomach.

Summary of post-mortem appearances.—To recapitulate, then, the important lesions found after death from hog cholera are as follows:

1. Reddening of the skin.
2. Bloody spots in the lungs, on the surface of the heart, in the kidneys, on the outer surface and inner lining of the intestines and the stomach.
3. Reddening of the lymphatic glands.
4. Enlargement of the spleen.
5. Ulceration of the inner lining of the large intestine.

Any one or all of these lesions may be found in a hog which has died from hog cholera. It is rare to find all in any individual case, although at times we do find a perfectly typical picture showing all of the lesions described above. On the contrary, it has also been noticed that hogs suffering with a virulent form of hog cholera may at autopsy show only an enlarged spleen or a hemorrhagic or bloody condition of the lymphatic glands. In the lingering or chronic cases of hog cholera it is usual to find the intestinal button-like ulcers, while the hemorrhagic lesions described above are, as a rule, absent.

DIAGNOSIS.

From what has already been said of the symptoms exhibited by hogs sick of hog cholera, it will be recognized that at the beginning of an outbreak in a herd it is a difficult matter to be sure that hog cholera is actually present, for the outward symptoms are not characteristic, but only such as might be expected in any acute disease. The same may be said of some of the changes which take place in the internal organs. It is therefore necessary to consider all of the features of the disease before making a positive decision concerning the presence or absence of hog cholera in a herd.

The important features of hog cholera are:

1. Contagiousness.
2. Symptoms of severe illness, such as fever, weakness, loss of appetite, and diarrhea.
3. Hemorrhagic spots in the internal organs or button-like ulcers in the intestines. (See figs. 2 and 3.)

If these characteristics are found in a disease of hogs in this country, we may be reasonably certain of the presence of hog cholera.

DISEASES WHICH MAY BE MISTAKEN FOR HOG CHOLERA.

Among the few diseases which may lead to uncertainty are digestive troubles (due to improper feeding), swine plague, tuberculosis, anthrax, and inflammation of the lungs caused by worms.

SICKNESS CAUSED BY IMPROPER FEEDING.

Although hogs are frequently made sick by improper feeding, there is rarely any cause for mistaking such illness for hog cholera, the only trouble of this character which is likely to give rise to confusion being in the case of swill-fed hogs. Dr. V. A. Moore has reported a disease among swill-fed hogs which closely resembled hog cholera and which was directly traceable to the presence of powdered soaps in the slops. Some of these soaps contain a large amount of alkali, and when mixed with the garbage used for feeding hogs will bring about lesions in the internal organs which are very similar to those seen in hog cholera. In most cases it will probably not be difficult to distinguish such a disease from hog cholera, especially if the mode of feeding be considered. If the illness is due to the presence of alkali in the swill, a change of food should result in a prompt improvement in the condition of the animals. If this does not occur, then, of course, hog cholera or some other germ disease should be at once suspected.

SWINE PLAGUE.

It is not practicable for a farmer to attempt to distinguish between hog cholera and swine plague, for, while swine plague is generally regarded as a lung affection, and hog cholera as a disease of the intestines, the fact is that practically all of the lesions which are found in cases of hog cholera have also been reported as being present in outbreaks of swine plague. There is at present a tendency on the part of those who have investigated these diseases to regard both hog cholera and swine plague as being caused by the same invisible germ, the predominance of lung lesions in one case and intestinal inflammation in the other being caused by the action of different germs which attack the hog after it has been made sick by the invisible germ which is looked upon as the prime cause of the disease in both cases. However this may be, it is quite safe to say that the great losses which occur among hogs in this country are brought about by hog cholera, and that, for the present at least, we may ignore the existence of swine plague as a separate disease, especially as the general measures for controlling it are the same as those required in cases of hog cholera.

TUBERCULOSIS.

The distinguishing features between hog cholera and tuberculosis are that in the case of tuberculosis the onset of the disease is slow rather than sudden, as is the case in hog cholera; likewise the progress of the disease is very slow, and the symptoms exhibited by the hogs which are affected are those of general unthriftiness rather than of acute illness. Tuberculosis does not show a tendency to spread rapidly through a herd of hogs, as is the case in hog cholera, and the deaths, if any occur, will in the vast majority of cases follow a very prolonged illness. It is extremely rare that an apparently healthy hog will die quickly from tuberculosis. It is possible, of course, for a whole herd to show signs of tuberculosis at about the same period, because of having previously contracted the disease from the same source and at the same time, as, for instance, through the feeding of tuberculous skim milk. But in this case the hogs have caught the infection from the skim milk, and not from each other.

In cases of tuberculosis the post-mortem changes which may be found in the organs consist of whitish or grayish consolidated areas in the lungs, with sometimes a yellowish cheesy-like center. Similar areas, though not so large, are found in the liver, and in the case of the spleen we find nodules of varying size, some as large as an acorn. These nodules project above the surface of the spleen. They are whitish looking, and when cut are found to be of a tough, fibrous nature, the appearance of this organ being entirely different from that found in hog cholera. In tuberculosis the bloody points in the kidneys are absent, but ulcerations may be found in the intestines. These are usually in the small intestine rather than in the large intestine, and instead of being round and raised and button like, as in hog cholera, they are rather irregular in outline and depressed below the surface of the surrounding healthy tissue, indicating a destruction or eating away of the inner lining of the intestines.

Tuberculosis frequently affects the lymphatic glands, but the changes which this disease causes can hardly be mistaken for lesions of hog cholera, for in tuberculosis the inner portion of the gland is broken down to a yellowish, cheesy mass which is not at all like the lesions of hog cholera.

ANTHRAX.

Hogs are rarely affected by anthrax, but when this disease does occur it might be readily mistaken for the acute type of hog cholera. The distinguishing features of anthrax in hogs are the marked swelling of the throat and tongue, with frequently a bloody froth in the mouth, and further by the fact that anthrax in hogs usually follows disease in other animals on the farm, horses, cattle, and sheep being more susceptible to anthrax than hogs.

LUNG WORMS.

Young, growing pigs are at times attacked by lung worms, which bring about an inflammation of the air passages. The most important symptoms produced by these are general unthriftiness, and a hard cough. Old hogs are rarely attacked and the younger hogs usually recover. The worms that produce this trouble are very small (one-half to 1 inch in length) and examination of the frothy expectoration of sick hogs or of the lungs after death is usually required to make a positive diagnosis. In this disease there is an entire absence of symptoms of acute illness such as usually accompany an attack of hog cholera. This fact coupled with the cough would point to lung worms; examination of the lungs and expectoration with a magnifying glass will serve to clear up doubtful cases.

PREVENTION AND TREATMENT OF HOG CHOLERA.

GENERAL PREVENTIVE MEASURES.

All that is necessary to prevent hog cholera is to keep the germ of the disease away from the herd. It has been shown that in the vast majority of cases this germ is transported mechanically, in the bodies of sick hogs and on the feet of men or animals, including birds. It thus follows that the chances of an outbreak of hog cholera will be greatly lessened, if not completely avoided, if a herd is protected from these carriers of the infection. The enforcement of a complete quarantine is, however, not practicable under average farm conditions, and the best that can be hoped for is the lessening of the opportunity for infection by placing the herd on a part of the farm that will be the least accessible to men or animals from other farms. Hog lots should never be located near public roads if this can be avoided. All newly purchased stock should be kept separate from the main herd for at least thirty days.

In addition to protecting the herd by methods of quarantine, careful attention should be given to the general health of the herd. The hogs should be provided with clean, dry sleeping places, and the lots and feeding troughs should be kept clean. It is well occasionally to scatter slaked lime about the lots and to wash and disinfect the troughs. Probably the best disinfectant for this purpose is the compound solution of cresol (U. S. P.), which can be prepared at any drug store. One part of this should be mixed with 30 parts of water and the troughs scrubbed with it. The disinfectant is then washed out of the troughs with water.

After an outbreak of hog cholera the yards and pens should be thoroughly cleaned, all dead hogs should be burned or buried deep with quicklime, the litter should be collected and burned, and lime scattered freely over the ground. The sheds and hog houses should be washed thoroughly with the solution of cresol as above described before new stock is brought on the place. Feeding troughs that have been used by sick pigs should be burned if made of wood, but if this is not practicable they should be scrubbed clean and thoroughly soaked with the cresol solution, the latter being washed out before the troughs are used again.

It is possible to start an outbreak of hog cholera in a herd by bringing hogs on the farm that have had the disease and have apparently recovered. We have no definite information concerning the length of time that such hogs may be able to communicate the disease to others, but for safety's sake two or three months should be allowed to elapse after complete recovery before placing such an animal with susceptible pigs, and then only after washing or dipping in a disinfectant solution (compound solution of cresol, 1 to 100).

In Farmers' Bulletin 24, Dr. D. E. Salmon gave the following formula for a medicine which was used many years ago as a preventive and cure for hog cholera:

	Pounds.
Wood charcoal	1
Sulphur	1
Sodium chlorid	2
Sodium bicarbonate	2
Sodium hyposulphite	2
Sodium sulphate	1
Antimony sulphid (black antimony)	1

Experience has shown, however, that this medicine is not to be regarded as a cure or preventive in the true sense of the words, but it is nevertheless a very good condition powder. This powder is mixed with the feed in the proportion of a large tablespoonful to each 200 pounds weight of hogs to be treated, and should not be given oftener than once a day. This medicine can not be relied upon to prevent the occurrence of disease, except in so far as it improves the general health of the hogs. Therefore, even though this remedy be used, strict attention must be given to quarantine and sanitary measures if the disease is to be warded off when in the neighborhood.

PREVENTION BY INOCULATION.

Careful and persistent attention to general preventive measures, such as quarantine, disinfection, proper feeding, etc., on the part of farmers generally would no doubt result in a material reduction in the yearly losses from hog cholera, and the importance of observing these precautions can not be overestimated. However, as it is regarded as impracticable to enforce a general and completely effective quarantine, the Bureau of Animal Industry has endeavored for a number of years to find a medicine or serum which could be used for preventing hog cholera or for curing hogs sick of that disease. It is a well-known fact that hogs which have recovered from hog cholera are thereafter immune against that disease. The experiments of the Bureau of Animal Industry resulted in the discovery that when such immunes are injected with blood from a sick hog the immune is not made sick, but as a result of this injection its blood acquires the power to protect other hogs from hog cholera. The details of the early experiments which served to establish this fact are given in Bureau of Animal Industry Bulletin 102.[a] Since that bulletin was issued a great deal of additional work has been carried out, and it has been established beyond question that the early observations were correct and that it is entirely possible to protect hogs if they are treated with serum from a properly treated immune hog.

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[a] Can be obtained only from Superintendent of Documents, Government Printing Office, Washington, D. C.; price, 15 cents.

The method of producing this serum is briefly as follows:

A vigorous immune hog—that is, one which has recovered from an attack of hog cholera or one which has been exposed to the disease without contracting it—is treated with a large quantity of blood from a hog sick of hog cholera. After a week or two blood is drawn from the immune by cutting off the end of the tail. After standing, the blood clot is removed and the serum or fluid portion of the blood is mixed with a weak solution of carbolic acid and filled into sterilized bottles. We have in this fluid portion of the immune's blood the serum which will protect hogs from hog cholera. This serum is used in either one of two ways, namely, (1) the serum inoculation, and (2) the simultaneous inoculation. These two methods of treatment are carried out as follows:

Serum inoculation.—The hogs which are to be protected are injected on the inside of the hind leg with a suitable dose of the serum alone. This injection will serve to protect hogs from hog cholera for several weeks and, in some cases, for a longer time. But if the hog is not exposed to hog cholera within a few weeks after this treatment, the immunity which is conferred by the serum will gradually lessen in degree and the hog may again become susceptible. If, however, the hog is exposed to hog cholera within a short time after the injection of the serum, the immunity becomes, so far as experiments have shown, of permanent and lifelong duration.

From what has been said it will be seen that the injection of the serum alone is especially to be recommended in cases where there is immediate danger of exposure, especially when valuable hogs are carried to fairs and in herds where the disease has already broken out but has not progressed very far. In herds of this character all of the well animals may be treated, and even in the case of slightly sick animals much good may be accomplished by the serum injection.

Simultaneous inoculation.—In this form of vaccination the same serum is used as is employed when the serum alone is used, but in addition to the serum there is injected on the opposite side of the body, in the same manner as the serum, a very small amount of blood taken from a hog sick of hog cholera. This simultaneous injection of serum and virulent blood confers upon the injected pig a permanent and lasting immunity, and is therefore to be recommended in cases of well herds which may not be exposed for some months after the treatment.

Safety of the methods.—Properly prepared serum when used alone, without the employment of blood from a sick hog, is entirely harmless and incapable of giving rise to an attack of hog cholera. Nor does this injection interfere in any way with the growth of the treated hogs.

The simultaneous inoculation, involving as it does the use of a disease-producing virus, requires much more care when employed than does the serum-alone inoculation, for, if through careless preparation or from any other cause the serum should be weaker than is required, injury to the vaccinated hog might result. This danger, which is extremely slight when carefully tested serum is used, is met with in practically all processes which are now employed for producing a permanent and lasting protection against infectious diseases, and although it would be very desirable to eliminate even this slight element of danger, we can hardly expect to do this without at the same time sacrificing to some extent the high degree of immunity and the prolonged protection which follows the simultaneous method in its present form.

Practically, in deciding which method to use one must be governed largely by the length of immunity which is required. If this is needed for only a few weeks, or if the treatment can be repeated at short intervals, as in the case of exceptionally valuable pure-bred hogs, where the increased cost would not be objected to, the serum alone may be used. In other cases the simultaneous method is recommended. In either process of vaccination it is considered highly desirable for the treatment to be applied by competent veterinarians who have had special training in this class of work, and only such skilled men should employ the simultaneous process. After treatment by the simultaneous method the herd should be kept under observation for ten days or two weeks, and if any of the inoculated hogs show serious symptoms of disease the herd should be immediately re-treated with the serum alone. When properly performed, the simultaneous inoculation does not seem to injure the hog or to interfere with its growth in any way, and if the precautions indicated above are taken it is regarded as safe enough for practical use.

Practical tests of both methods.—As before stated, the serum has been tested by the Bureau of Animal Industry in an extended manner on farms under practical conditions, both the serum inoculation and the simultaneous inoculation being employed at different times. In these practical experiments a number of hogs were generally left untreated, so that we might be sure that the herd actually had hog cholera and also be able to determine better the action of the serum. In these tests approximately 2,000 hogs, located on 47 separate farms, were treated. Some of the herds treated were apparently perfectly well at the time, but were in a neighborhood where hog cholera was prevalent. In other cases the disease was just beginning, as indicated by the sickness of one or two animals. In others the disease had progressed to a considerable extent, a number of the animals in the herd being sick at the time of treatment; and in still another class of herds the hogs had been exposed to disease by contact with sick animals, but had not developed symptoms of illness at the time of treatment. The tests were carried out under farm conditions, and aside from the serum injections no attempt was made to save the treated hogs. Upon summarizing the results at the end of the season it was found that more than 85 per cent of the treated hogs had been saved in herds that were sick at the time of treatment, while of the hogs left untreated in the same herds only 25 per cent survived; more than 95 per cent of the treated animals were saved in the herds which had been exposed at the time of treatment, while of the untreated hogs in the same herds only 11 per cent survived; of the treated hogs in the herds that did not become exposed until after the treatment none were lost, whereas only 35 per cent of the untreated hogs in the same herds survived.

While in practice the serum may not always give as good results as these, there can be no doubt that if used properly and in the early period of an outbreak of hog cholera it will effect a very large saving.

CONCLUSION.

Since these results were obtained the Department has brought this method of preventing hog cholera to the attention of the various State experiment stations and live-stock sanitary boards throughout the country and has proposed to them that they take up this work and prepare a serum for the benefit of hog raisers, as the preparation of serum by the Federal Government on a large enough scale to supply the needs of the entire country seemed to be impracticable. As a result of this, a number of the States have taken up the work, and in practically all cases where a thorough test has been made they have confirmed the results obtained by the Department with this method. We therefore feel safe in saying that this process will prevent hog cholera, provided due care is given to the preparation of the serum and to its application.

The serum preparation is of such a nature that it should not be undertaken by farmers themselves, but should be under the control of trained men who have had experience in bacteriology and who are also thoroughly familiar with the diseases which affect hogs. For these reasons no attempt has been made in this paper to describe the details of the serum production.

At the present time it is impossible to state definitely just what the cost of this serum should be. This will undoubtedly vary in different localities, depending upon local conditions, such as the price of hogs, the cost of feed, and similar minor considerations; but it has been estimated, and this estimate has been confirmed by at least one of the States now conducting this work, that the serum can be made for 25 cents a dose. We do not regard this as the minimum limit of cost for the serum production, but rather hope that with increased knowledge of the disease and wider experience with the serum production this estimate will be materially reduced.

Finally, it should be remembered that this serum is to be used especially as a preventive, and that little success can be expected in herds which are badly affected with hog cholera. An early application is essential, and in the States which have taken up this work the farmers should notify the proper authorities immediately upon their hogs becoming ill, so that they may be treated at once.

Inasmuch as the serum described herein is a comparatively new substance, it is not to be expected that success will always follow its use, but as it has been already definitely proved that hog cholera may be prevented with this serum, the failures, if they occur, will be caused by local conditions or variations in the details of serum production, which can be corrected. Those who are interested in the subject are urged to cooperate with the State authorities who have control of this work and to assist them in their efforts to produce a reliable serum. It is only through such intelligent cooperation that we can expect to attain the final result which is aimed at, namely, the eradication of hog cholera as a serious menace to the hog-raising industry in this country.

NOTE.—The United States Department of Agriculture is not preparing anti-hog cholera serum for distribution. Those who wish to obtain serum should apply to their respective State veterinarians or agricultural colleges.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 380.

THE LOCO-WEED DISEASE.

BY

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Expert, Poisonous-Plant Investigations, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 15, 1912.

Sir: We have the honor to transmit herewith and to recommend for publication a revision of Farmers' Bulletin 380, entitled "The Loco-Weed Disease," by Dr. C. Dwight Marsh, Physiologist, Poisonous-Plant Investigations, Bureau of Plant Industry.

A detailed account of the laboratory investigations of Dr. Albert C. Crawford upon the cause of "loco" poisoning has been issued as Bulletin 129 of the Bureau of Plant Industry. A technical companion bulletin upon the field investigations of "loco" by Doctor Marsh has been issued by the Bureau of Animal Industry as Bulletin 112, to which readers interested in an extended account of the experiment and wishing to see illustrations of the "loco" plants and of animals affected with the disease are referred.

An investigation of the relation of barium to the loco-weed disease from the field side by Doctor Marsh and from the laboratory side by Doctor Alsberg and Mr. Black has been published as Bulletin 246 of the Bureau of Plant Industry.

The present bulletin, the original edition of which was issued November 10, 1909, in response to a great demand for immediate information upon the outcome of these investigations, is a brief practical presentation of the results of the work upon the "loco" disease and is intended to meet the needs of ranchmen and stockmen on the western ranges and the National Forests.

Respectfully,

B. T. Galloway,
Chief, Bureau of Plant Industry.
A. D. Melvin,
Chief, Bureau of Animal Industry.

Hon. James Wilson,
Secretary of Agriculture.

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THE LOCO-WEED DISEASE.

INTRODUCTION.

The word "loco" is of Spanish origin, meaning crazy, and has been popularly applied for a long term of years to a disease common among horses, cattle, and sheep in the Great Plains region of the West. The first printed record of this disease seems to have been in the Report of the Commissioner of Agriculture for 1873, and the descriptions of the symptoms of locoed animals in this and the succeeding reports of the United States Department of Agriculture are among the best written.

The losses of horses, especially in parts of Texas, have at times been very large, while in some localities in Colorado, Nebraska, and Kansas it has been found impossible to run horses freely upon the range because of the large number that die from this disease. The losses of cattle have been heavier, perhaps, in Colorado than in any other State, while the losses from locoed sheep have occurred more frequently in the States farther north, especially in Montana.

A large amount of investigation, both in the field and in the laboratory, was carried on in past years, but the results were very contradictory. Many people were convinced that while there was a diseased condition among the stock which doubtless caused very heavy losses, this was due to food or other causes rather than to any specific poisonous effect produced by eating plants. The majority of stockmen, however, were convinced that the disease was caused by eating certain plants, which on this account were known to them as "loco plants."

LOCO PLANTS.

A large number of plants have been called by the name "loco weeds," most of those which were suspected of being poisonous belonging to the botanical family Leguminosæ, to which belong also the pea, alfalfa, and other similar plants. In western Texas, western Nebraska, western Kansas, and in portions of eastern Colorado the term "loco weed" was applied specifically to the plant known to botanists as *Astragalus mollissimus*.

THE PURPLE LOCO WEED.

Astragalus mollissimus, popularly known as the "purple loco" or the "woolly loco," sometimes as the "Texas loco" or the "true loco" (fig. 1), is the plant that in the past has been considered as the more probable cause of loco poisoning. This is sometimes known as the "stemmed loco plant," because it has true stems, while the white loco weed (*Aragallus lamberti*) is stemless. The former is a perennial plant growing in patches on adobe soil, in depressions rather than in elevated situations. It rarely grows in the abundance which is characteristic of some of the other so-called "loco plants," but it may cover several acres. Under favorable circumstances, where a plant grows for several years, it may become, perhaps, a foot in height and possibly 2 feet in diameter. The flowers are a very deep purple and the pods short, black, and thick. The leaflets are ovate or elliptical and very densely covered with hairs, from which the plant gets its common name of "woolly loco." The plant has a decumbent habit; that is, the long branches are inclined to lie rather close to the ground.

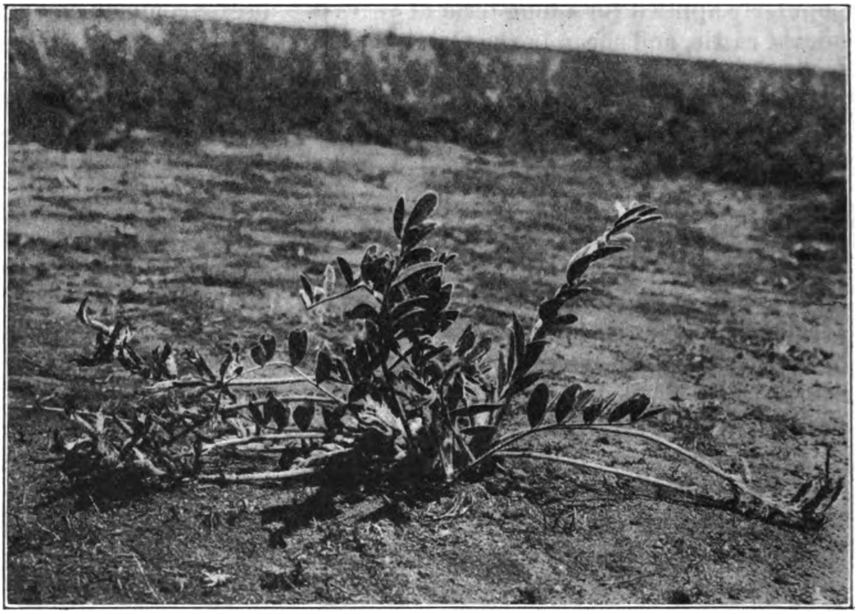

FIG. 1.—A plant of the purple loco weed (*Astragalus mollissimus*).

The purple loco plant is found as far north as South Dakota, as far south as Mexico, and as far west as parts of Arizona. Its eastern limit may be stated as central Kansas and Nebraska and the western part of Oklahoma. (See fig. 2.) In these regions it grows in varying abundance. It blossoms in Colorado about June 1, but farther south—in New Mexico, for instance—blossoms are found early in April.

THE WHITE LOCO WEED.

The white loco plant (*Aragallus lamberti*) (fig. 3) is distinguished from the purple loco by its long lanceolate leaves and by the general habit of the plant, which is erect rather than decumbent. It has no true stem, and on this account is sometimes called the "stemless loco." The flowers are ordinarily on long flower stems and commonly are white in the Plains regions, although there is considerable variation in their color. Purple flowers are not uncommon. In the mountain regions the white loco ordinarily has very deeply colored flowers—deep shades of violet and purple. It blossoms earlier than the purple loco. Plants blossom in Colorado in the latter part of April, and early in the summer the flowers disappear and the pods are found upon the still-erect flower stems. The pods of *Aragallus lamberti* are slender and filled with seeds, which, when the pods dry, rattle as a person passes through a patch of the plants, making a sound which closely resembles the warning of a rattlesnake. Hence it is sometimes called "rattleweed." It should be noted, however, that the locoes known as "rattleweeds" in California, Arizona, and New Mexico do not belong to this species. In this plant, as in the purple loco, there is an extremely long root, growing down from 3 to 6 feet.

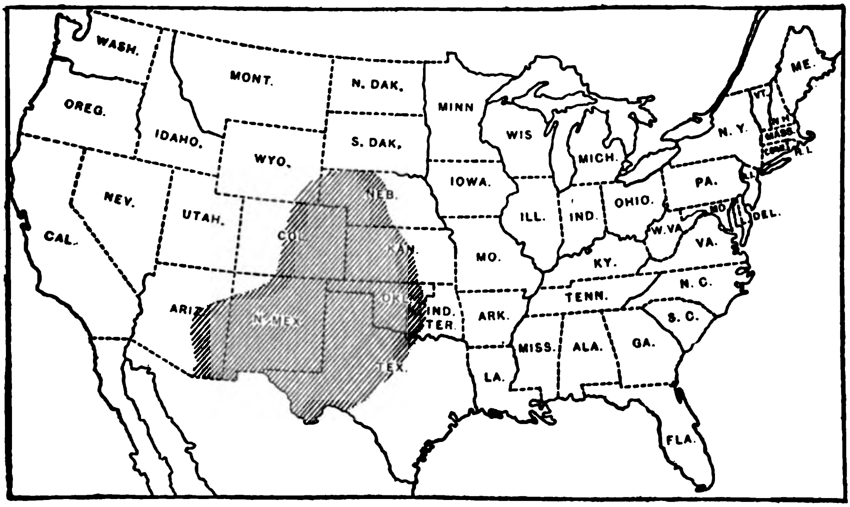

FIG. 2.—Map of the United States, showing the distribution of the purple loco weed.

The white loco is found much more widely distributed than the purple loco, extending from the northern to the southern border of the United States, as far east as central Minnesota and as far west as western Utah and Arizona. (See fig. 4.). It grows largely on elevations and on sandy soil, and in some places in very great abundance. In parts of Colorado, Wyoming, and Montana, at the time of blossoming, large areas are as white as though covered with snow, and in the more elevated regions of Colorado and Arizona the patches of beautiful dark-colored flowers are very striking.

Aragallus lamberti goes under the common names of "white loco" and "rattleweed." The term "white loco" in the mountains is, however, sometimes popularly applied to another leguminous plant. From the color of the flowers in the mountains it is also sometimes known as the "pink loco."

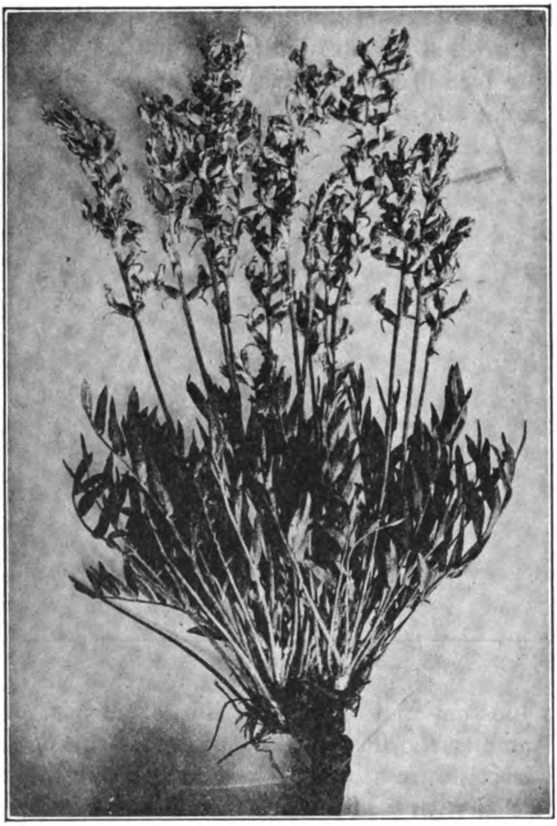

FIG. 3.—A plant of the white loco weed (*Aragallus lamberti*) in flower.

OTHER LOCO WEEDS.

The experimental work in the field and in the pharmacological laboratory of the Bureau of Plant Industry has been largely upon the two species known as the purple loco and the white loco. These are the weeds which produce the disease from Montana to northern New Mexico and Arizona and in western Texas. In parts of New Mexico, Arizona, and California there are found great numbers of locoed animals in localities where neither of these two species grows. Other leguminous plants in these places are known as loco weeds, and while the field investigations and laboratory tests of these plants have been very incomplete, it has been proved that some of them are poisonous, and the symptoms of locoed animals and the pathological findings are similar to those produced by the Colorado plants.

Astragalus diphysus, *Astragalus arizonicus*, *Astragalus thurberi*, and *Astragalus bigelovii*, plants growing in New Mexico and Arizona, are doubtless loco weeds, although they have not been subjected to detailed experimental work. There is good reason for believing not only that these plants are poisonous, but also that they are considerably more toxic than *Astragalus mollissimus* and *Astragalus lamberti.* The evidence seems to be good, too, that *Astragalus nitidus*, a species growing in the mountains of Colorado and adjacent States, is a true loco.

Investigations of some other plants are now being carried on by the Bureau of Plant Industry, and it seems probable that a considerable number of leguminous plants are poisonous and can properly be known as loco weeds.

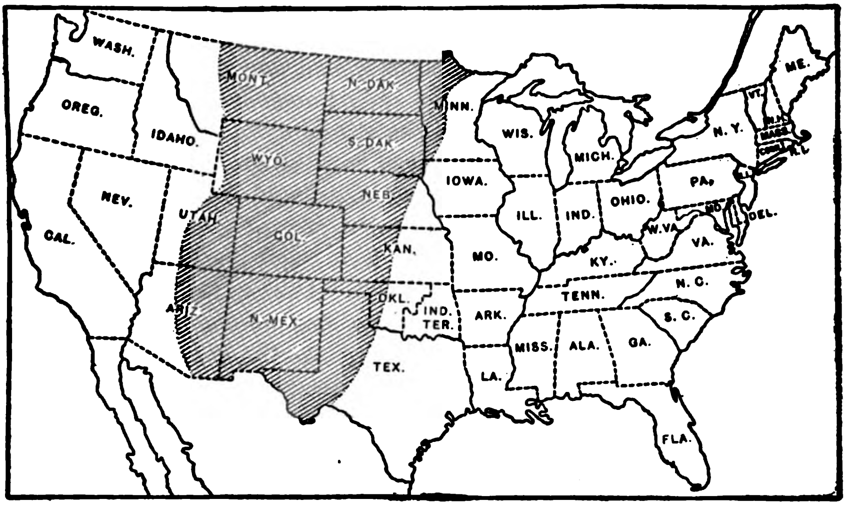

FIG. 4.—Map of United States, showing the distribution of the white loco weed.

POISONING BY LOCO PLANTS.

It was found when the loco investigation was undertaken by the Bureau of Plant Industry that there was a very general belief among stockmen that the purple loco weed was a poisonous plant and a less general belief that the white loco weed was injurious.

The field work which has been carried on during the past few years has demonstrated that horses, cattle, and sheep in the field can be poisoned by feeding upon these two plants. It has also been shown very clearly that the purple loco weed is very rarely injurious to cattle. In those sections where the purple plant is the only loco weed known, the losses from poisoned stock are found to consist almost exclusively of horses. This seems to be because cattle will not readily eat this plant. The experiments show that under ordinary circumstances most cattle would prefer to starve rather than to eat any of the purple loco weed. The majority of horses do not take readily to this plant except as they are induced in the first place to eat some of it because of short feed. It has been demonstrated that the so-called loco disease of the plains is not simply a matter of starvation, as has been supposed by many, and it is also clear that when other food is abundant very few horses will eat loco. When, however, because of shortness of grass a horse is induced to begin the eating of loco, it is very likely to contract a habit which leads to continued feeding upon the weed, with eventually fatal results.

In regard to the white loco weed the experiments showed very clearly that horses, cattle, and sheep will eat this plant with great readiness, particularly if they come across it at a time when grass is somewhat scarce. Both the white and the purple loco weeds are green during the winter, when all grass on the plains is dry and brown. They are prominent plants, too, which induces an animal to try them, and because of their succulent character and somewhat pleasant taste it may continue to eat them. Not only horses but cattle and sheep will eat the white loco weed, and sometimes even with great avidity. Many animals will eat this weed even when grass is abundant, but it is more common for the habit to be contracted during the autumn, winter, and spring, when there is a scarcity of green grass. Both horses and cattle will eat the white loco weed readily, but perhaps cattle take to it more readily than horses. During the spring months, before the grass starts, where the white loco weed is abundant practically all animals eat more or less of it. As the grass becomes more abundant many of these leave the loco weeds and devote themselves entirely to grass. These animals as a rule do not seem to be injured by the habit. Others, however, acquire a taste for the plant and an appetite which is not easily overcome, and they will continue to eat the loco weed even where there is an abundance of other feed. Whether an animal will become locoed or not is then simply a matter dependent upon the individual. Some cattle and horses will eat loco weeds during a part of the year for a period of years and suffer no harm. Others acquire a habit which leads them to eat this plant almost exclusively, and these will die within a few months, or in some cases even within a few weeks.

Sheep also are poisoned in much the same way as horses and cattle. The effect of the poisoning seems to be peculiarly noticeable on lambs. Frequently lambs will die within two weeks of the time when they commence to eat this weed and without any marked loss of flesh.

It should be said, perhaps, in this connection that there is considerable difference in the readiness with which various breeds of animals will eat loco weeds. It is a matter of common observation upon the plains that the so-called "native breeds" are very much less likely to be locoed than are imported animals. This, of course, is as one would expect from the fact that the imported animals are not familiar with the plants and in many cases do not have the quality of "rustling," so that they are inclined to eat the food which is most easily obtainable rather than seek more suitable plants. Generally speaking, the finer breeds of cattle and horses are more likely to be locoed than the poorer breeds. The same thing is true of sheep, it being particularly noticeable that the black-faces are much more apt to be locoed than are the merinos.

SYMPTOMS OF POISONING IN HORSES.

The first symptom of loco poisoning in horses is often a change in the general condition of the animal. If high-lived the animal becomes somewhat dull. Following this, irregularities in its gait and in its mode of eating appear. The irregularities in the gait may be due partly to weakness and simulate a paralytic affection. The horse drags its feet more or less, this being particularly noticeable in the hind legs. Associated with this paralytic condition is an apparent loss of muscular coordination. In stepping over a slight obstruction the horse lifts its feet unnecessarily high, or in going over a rut in a road it may leap as if jumping over a ditch. As the disease progresses, the animal becomes solitary in its habits and seems to lose very largely its nervous sensibility. If one approaches a badly locoed horse the horse does not notice the person until he is within a few feet, when it may suddenly rear and perhaps fall over backward. When it drinks or when it eats there is a peculiar stiff motion of the jaws, showing a lack of control of the muscles. If a locoed horse is used either in riding or driving, this lack of muscular coordination may make it extremely dangerous, as such a horse shies violently at imaginary objects, can not readily be led or backed, and if started in motion is inclined to go in an automatic fashion at the same gait until stopped by some obstruction. In the later stages of the disease the animal loses flesh, its coat becomes rough, and eventually it ceases to eat and dies.

SYMPTOMS OF POISONING IN CATTLE.

The symptoms of locoed cattle are very similar to those of locoed horses, the differences being only such as would be expected from the different character of the nervous organization of the animals. There is the same lack of muscular coordination, and while a steer is not apt to fall over backward it will start and tremble and perhaps rear and jump backward when suddenly alarmed. A badly locoed steer shows a violently shaking head, particularly after it has become heated. Ordinarily a locoed steer is dull, but under some conditions it may become frantic and will run into obstructions in an utterly unreasonable way. It is commonly said by stockmen that it is impossible to drive a locoed steer, because it is just as likely to run into the driver as in the opposite direction.

Locoed cattle gradually lose flesh, have staring eyes and rough coats, go to water less and less frequently, and eventually die of starvation.

SYMPTOMS OF POISONING IN SHEEP.

The symptoms of poisoning in sheep are not so marked as those in horses and cattle. The lack of muscular coordination is not so noticeable; still it exists. Locoed sheep show, perhaps, more clearly the weakness which goes with the disease, as they stumble and fall, and rise again only with great difficulty. The symptoms of loco poisoning in sheep resemble the symptoms caused by "grub in the head," or *Oestrus ovis*, and it is at times difficult to distinguish between sheep affected by this grub and those that are poisoned by loco weeds.

POST-MORTEM APPEARANCES.

The post-mortem examinations of locoed animals do not in all cases show clearly marked evidence of the progress of the disease. Since in all cases of fatal poisoning the locoed animals die of starvation they are profoundly anæmic, as would be expected, and, as a result of this anæmia, accumulations of coagulated serum in a gelatinous form are found in various parts of the body. These accumulations are particularly prominent about the heart. There is also an accumulation of coagulated serum in the cavity of the spinal column. This is almost always present in cases where the loco poisoning has become a chronic condition. The nervous system is more fully supplied with blood than is the case with an animal in normal condition. This, however, is not a very pronounced feature, and the blood clots which are occasionally found in the brain are not so evident as would be expected from the accounts published in the literature upon loco poisoning.

The poisonous substance in the loco plants produces an irritant effect upon the stomach and intestines, and in the larger number of locoed animals this results in an inflamed condition of the walls of the stomach. It is common to find ulcers in the pyloric end of the stomach of horses and similar ulcers in the fourth stomach of cattle and sheep.

RESULTS OF LABORATORY INVESTIGATIONS.

Dr. A. C. Crawford, pharmacologist in the office of poisonous-plant investigations, found that the purple loco in laboratory tests was more toxic than the white and that the plants from New Mexico and

Arizona, namely *Astragalus diphysus*, *Astragalus thurberi*, *Astragalus arizonicus*, and *Astragalus bigelovii*, were more poisonous than the loco plants of Colorado. He also found barium present in all loco plants, the more toxic having the greater quantity. The inference, however, that barium is the cause of the peculiar toxic characteristics of the loco plants has been shown both by field and laboratory experimentation to be unfounded. Dr. Alsberg and Mr. Black have made extended studies of the loco plants which confirm the preceding work in regard to the relative toxicity of the different species and have very greatly increased our knowledge of the chemistry of the subject.

TREATMENT OF LOCOED ANIMALS.

Experiments with substances which would be logical antidotes for loco poisoning have been disappointing, and at the present stage of the investigation there seems to be no reason for hoping that a practical antidote can be found. During the course of the experimental work which was carried on in Hugo, Colo., however, attempts were made to treat the animals in accordance with the more pronounced symptoms, and this treatment was so successful that it can be said that it is possible to bring most animals out of the locoed condition and restore a large part of their value, provided the animals are worth enough to warrant a somewhat extended course of treatment.

The first, and without any doubt the most important, part of the treatment is the food. As a matter of fact, many locoed animals, especially in the earlier stages of the disease, can be cured by simply taking them away from the loco weeds and feeding them upon nutritious food like alfalfa and grain. All chronically locoed animals are constipated, and the food should be of such a character as to remove this condition. For this purpose alfalfa and oil meal have been used, although any other food having laxative properties would be useful. Probably nothing is better for locoed horses and cattle than to turn them, under proper precautions, into a field of alfalfa.

Where the constipation is of an obstinate character it has been found desirable to give doses of Epsom salts. The dose used in experiments with mature cattle was about 1 pound, given in the form of a drench. For younger animals the dose was smaller, calves receiving not more than 2 ounces. For horses the dose should be about 8 ounces and for full-grown sheep 4 ounces. These doses varied with the size and condition of the animal, but commonly rather small doses were found sufficiently efficacious. It was not necessary to repeat the treatment many times, provided care was taken to give food of a laxative character.

A large number of experiments were made to determine what remedy would be best to improve the nervous condition of horses and cattle, and the results seemed to show that for horses nothing was better than arsenic in the form of Fowler's solution, while for cattle the best success was obtained by the use of strychnine. The Fowler's solution was given in daily doses of 4 to 6 drams, or 15 to 20 cubic centimeters, in the grain or in the drinking water of the horses. These doses should be continued for a considerable period, the time varying with the individual animal, but ordinarily for not less than one month.

The strychnine was given in hypodermic doses, the cattle being run through a chute and treated one after another. Locoed animals are very sensitive to strychnine, and it was found necessary to give it in extremely small doses. The daily doses should not ordinarily exceed three-twentieths or four-twentieths of a grain, or 0.009 to 0.012 of a gram. Large animals may take as much as one-half grain, but this is a maximum dose and often will be found too much. This treatment should be continued, as in the case of Fowler's solution, for a considerable time, ordinarily 30 days or more. The fact should be emphasized that the doses of strychnine should be very small. It was found that animals could very readily be killed with what are considered the common veterinary doses, but in small quantities the results were distinctly beneficial.

It was also found that sodium cacodylate when given to cattle daily in hypodermic injections of 6 grains, or 0.4 gram commonly gave beneficial results. The best results, however, were obtained from the use of strychnine and Fowler's solution, as already outlined. Cattle in very bad shape were taken and after treatment were turned out in suitable condition to be sold for fat beef, while horses which were absolutely worthless recovered and became entire usable, although probably they were not in as good condition as they would have been if they had not been poisoned. The experiments show conclusively that if horses or steers are considered valuable enough to be treated in this way the majority can be brought into good condition.

The fact should be emphasized that very rapid recoveries can hardly be expected. The condition existing in a case of chronic loco poisoning has been brought about gradually by weeks or months of loco feeding, and the rate of recovery must necessarily be rather slow.

Very much can be accomplished in the way of preventing loco poisoning by the proper handling of stock. It has already been stated that it is in times of short feed that the stock commonly contract the habit of loco feeding. Feeding hay during this period will prevent many animals from acquiring the habit. On some ranges the loco weeds have a rather definitely limited distribution; in such cases, if kept away from the infested areas until the grass is started, few of the stock become locoed.

In handling sheep it is important to separate the locoed animals from the bands, because of the tendency of sheep to imitate each other; one locoed sheep may educate a great many to become loco eaters. On this account some sheepmen kill every locoed animal as soon as discovered, and this doubtless is the best way where it is impossible to handle the locoed animals by themselves.

DESTRUCTION OF LOCO WEEDS.

There is a common belief among the stockmen of the infested regions that in order to destroy the loco plants it is necessary to dig up the whole root, so that it has seemed to them almost impossible to clear a field infested with loco, even though the field is of comparatively limited extent. This impression in regard to the necessity of digging the whole root is false. If either the purple or the white loco weed is cut off below the crown of buds the plant is killed. There is no danger of sprouts from the roots. The seeds of these loco plants live for a term of years and do not all germinate the season following their growth. Consequently, in any field infested with loco there will be a continuous crop of plants, as these seeds under favorable circumstances germinate.

The impression that plants grow from the cut roots probably originated in the fact that seedlings are continually coming up in the immediate vicinity of a parent plant. The seeds of the purple and of the white loco weeds are not provided with any special means of dispersal by the winds. Ordinarily they fall near the parent plant and grow in that locality. Of course, the winds which move the dust of the surface will carry the seeds from one place to another, but under ordinary circumstances they are not dispersed for any considerable distance.

It follows that to cut out the loco weeds in pastures is a comparatively easy matter. A man with a spade can destroy the plants with great rapidity. A few days' work will accomplish much more than one would expect. Because of the seeds which germinate later, it is necessary for this work to be done two or three times during a season, and it is also necessary that it be repeated during succeeding seasons. It has been demonstrated at Hugo, Colo., that this is not a very laborious piece of work. The loco-free pasture which was used for experimental purposes was cleared the first year of the experiment by a few days' work, and with very little labor has been kept entirely free from loco since that time. The fact that the wind does not readily carry the seeds from one place to another prevents reseeding from other pieces of ground containing loco weeds, even when in the immediate vicinity. Where pastures are fenced it is comparatively easy, and certainly profitable, to dig out the loco plants. This is particularly easy in the case of the purple loco weed, for it rarely grows in any large quantity. The possibility of clearing pastures of loco weeds has been demonstrated by many ranchmen, as well as by the station force at Hugo.

Certain insects work upon the roots of the loco plants and in some cases occasion quite extensive destruction. At the time of the completion of the experimental work at Hugo the purple loco weed in Colorado, western Kansas, and Nebraska was destroyed to a very large extent by the larva of a moth known to entomologists as *Walshia amorphella*, and there is reason to believe that the work accomplished by the larvæ will reduce the quantity of the purple loco weed in this region to such an extent that for a few years loco poisoning from these plants will be very slight. Doubtless after several years the work of the insect will lose its efficiency and the plant will have another cycle of renewed activity. There are also insects working upon the white loco weed, especially the grubs of a weevil (*Cleonus quadrilineatus*), but so far they have not produced such destructive effects as have been noticed in the case of the purple loco. During exceptionally dry seasons very few of the loco plants germinate, and if at the same time the insects are abundant, as was the case during the summer of 1908, the numbers of loco plants become greatly reduced.[1]

SUMMARY.

(1) The purple loco and the white loco weeds produce the loco disease. The former is the more poisonous, but it affects horses almost exclusively, because other animals do not eat it. The latter is eaten by cattle and sheep, as well as by horses, and produces the disease in all of these animals.

(2) Other leguminous plants in Arizona, New Mexico, and California, locally known as "rattleweeds," produce the same symptoms as the purple and the white loco weeds and are supposed to contain the same poisonous substance.

(3) Locoed animals may recover under careful feeding, but the cure is hastened by the use of Fowler's solution for horses and strychnine for cattle.

(4) The purple and the white loco weeds may be eliminated from fenced pastures, and if the crown of buds is cut off they will not grow from the roots.

(5) In some localities much can be accomplished in the way of preventing loco poisoning by feeding horses, cattle, and sheep during periods of short feed and by keeping the stock away from infested areas.

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[1] Both of these species are treated more in detail in Bulletin 64, Bureau of Entomology, U. S. Dept. of Agriculture, pp. 33–42, which includes a list of all insects known to subsist on loco weeds.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 381.

Experiment Station Work,

LIV.

Compiled from the Publications of the Agricultural Experiment Stations.

METHODS AND COST OF CLEARING LAND.
TOBACCO IMPROVEMENT WORK.
CALF FEEDING.
GASOLINE-HEATED COLONY BROODERS.
MEASURING ACIDITY IN CHEESE MAKING AND BUTTER MAKING.

SEPTEMBER, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1909.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

METHODS AND COST OF CLEARING LAND.[b]

The problem of clearing logged-off land is an important one in various parts of the country, and although much of the farming is done upon land formerly occupied by forests, but little information regarding methods and costs of preparing this land for the plow has been recorded. Recently the Bureau of Plant Industry of this Department detailed Mr. H. Thompson to collect information from those who have had experience in this work in the Pacific Northwest, while the Mississippi Agricultural Experiment Station has issued a bulletin on the subject of clearing pine land containing the results of different methods tried there. The character of the clearing which is described by Mr. Thompson "ranges from the heavily timbered spruce and cedar lowlands through the benches and sidehills covered with fir stumps and a dense growth of underbrush to the more sparsely covered hemlock ridges." The information contained in these publications deals principally with the removal of stumps, which is the really serious problem of clearing land, and the methods described vary from grubbing the stumps out by hand to the use of the more costly and powerful mechanical devices.

Removing stumps by hand has proven a slow and costly method in the longleaf pine belt, while it is out of the question for the large stumps of fir and other trees up to 5 and 6 feet in diameter predominating in Washington and Oregon, and the principal up-to-date methods are burning, blasting, and pulling, or some combination of these. Burning is considered the best way to remove pine stumps, which have a large amount of turpentine, as this greatly assists in the process, and the long taproots of these trees are a great hindrance in pulling. In regard to burning these stumps Mr. Ferris, of the Mississippi Station, says:

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Mississippi Sta. Bul. 118; U. S. Dept. Agr., Bur. Plant Indus. Circ. 25.

> The common method * * * is to dig a hole about 12 inches deep with spade or post-hole digger on one side of the stump, as close to it as possible, and to use this as a furnace for firing the stump. In digging these holes it is necessary that the dirt be removed from as much of the surface of the stump as possible, so as to allow the fire to come in direct contact with the side of the stump for at least 6 inches. An ordinary turpentine dipper on a suitable handle makes one of the best implements for removing this dirt.

This is a rather slow process, but may be greatly hastened by boring a slanting hole through the stump from the opposite side to the fire hole. For boring, the Mississippi Station has used the simple machine shown in figures 1 and 2, invented by J. W. Day. It is thus described:

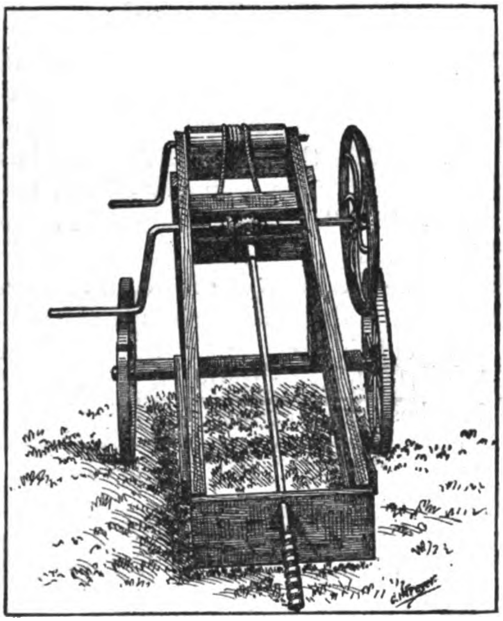

FIG. 1.—Stump auger, front view.

> A 2-inch ship auger is welded onto one end of a ¾-inch iron rod 6 feet long. Four inches from the other end of this rod a collar is welded and the end of the rod passed through an iron box fastened to a movable frame about 18 inches square. A bevel gear is then fastened to the extreme end of this rod either by a key or set screw and works into a second gear of the same kind fastened on a horizontal shaft. This horizontal crank shaft is made of 1-inch iron rod bent at one end to form a handle, with a fly wheel fastened on the opposite end. It works through two boxes fastened to the movable frame and slides down the main frame as the auger bores into the stump. The upper end of the machine is elevated about 5 feet and stands on two cart wheels, on which it is easily rolled from stump to stump or from field to field by a single individual. This elevation of the frame helps to brace it against the stump in boring, raises the crank shaft to a height at which it can be most easily turned, causes a slight pressure to be constantly exerted against the auger, and makes it possible to bore the hole diagonally into the stump. At the extreme upper end of the frame is a small windlass with ropes attached which is used for pulling the auger out of the stump.

This machine was used to aid in clearing 2.3 acres of land which had been cut over about seven years before. The sapwood had decayed, but the balance of the stump above ground and all below was sound. On this plat there were 158 stumps that required boring. These averaged 13.6 inches in diameter, and the length of hole bored averaged 19.7 inches, the total cost being less than $8 an acre, figuring labor at $1.50 per day.

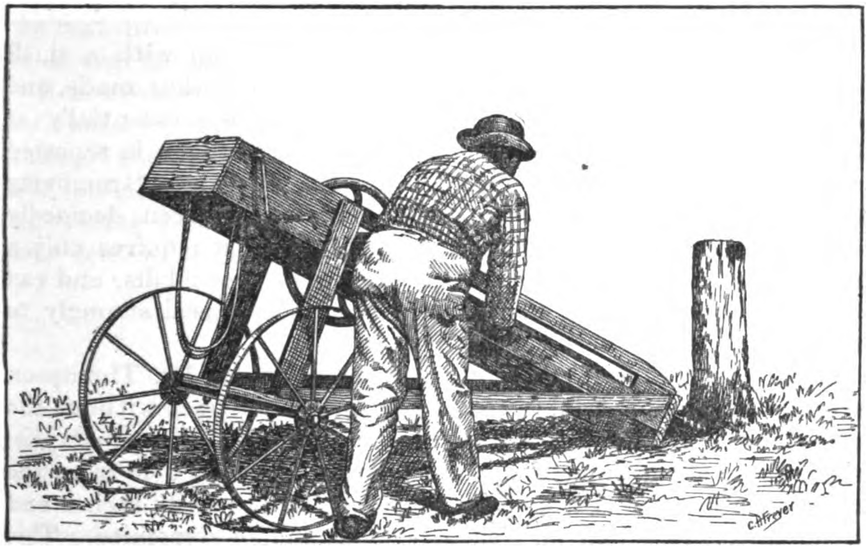

Fig. 2.—Stump auger, side view.

For burning the large stumps of fir, etc., in the Pacific Northwest, a quicker method is used, which consists of boring two intersecting holes, as in figure 3, and burning by starting a fire at the intersection with the aid of red-hot coals or a piece of iron heated to a white heat. After the part marked "A" is burned out, the fire is maintained by filling the space with bark and litter. While the method first described generally results in burning the stump low enough to

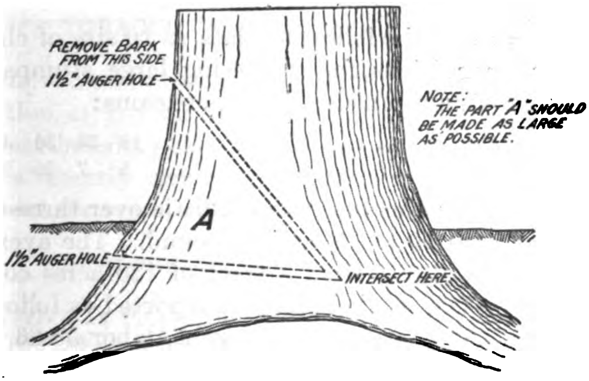

Fig. 3.—Method of preparing a stump for burning.

allow of cultivating over it in the case of pine stumps, the method used on the western trees leaves the larger stringers with their smaller roots to be pulled out by team or puller, or "they may be entirely burned by digging away the earth and rolling a small log alongside of the root."

Other methods of burning are to split the stump with a small charge of powder and then kindle a fire in the hole thus made, and charcoaling or pitting. The latter, which consists essentially of keeping a smoldering fire around the base of the stump, is reported to be very economical for large stumps. Mr. Ferris says "removing stumps by this method [boring and burning] has been decidedly cheaper than by any other method tried, and as it requires only a small expenditure for machinery, practically no repair bills, and can be operated by a single individual, it ought to appeal strongly to the small farmers of this section."

It is stated that in the section reported on by Mr. Thompson scarcely anyone undertakes to clear even a small tract without the use of powder. Powder is also used on the pine stumps of Mississippi, the common method being to bore a 1½-inch hole from the surface of the ground diagonally downward for 10 to 20 inches and to insert in this from one-fourth to 1 pound of dynamite. This amount will shatter the general run of pine stumps, and makes the cost of this part of the work from 5 to 20 cents per stump. With stumps of the fir type, which do not usually root deeply, blasting is best done by placing several sticks of dynamite beneath the center on the hardpan, if not too deep, so as to cause the force of the explosion to be exerted upward.

Mr. Thompson gives the following data as to size of charge, under ordinary ground conditions, for shattering large stumps which are to be removed by stump pullers, blocks, or teams:

Diameter of stumps in inches	18	24	30	36	48	60	72
Sticks of powder	5	7	10	20	35	50	65

The sticks are 1½ by 8 inches, weigh a little over three-fourths of a pound, and cost from 10 to 15 cents a pound. The average cost of the removal of each stump from a tract of 120 acres containing fir stumps from 1 to 4 feet in diameter was reported as follows: Powder 49.76 cents, fuse 2.37 cents, caps 0.87 cent, labor 30.66 cents, total 83.66 cents. If dynamite is handled with ordinary care there is but little danger attached to its use except in cold weather, when it should be kept warm, preferably at about 70° F.

After loosening and shattering stumps by blasting, it is necessary to gather them into a pile for burning. This is usually done by means of a capstan or a donkey engine. The latter is reported to have found quite general application in the Northwest. A gin pole is set up, as shown in figure 4, and the stumps drawn to it. When handled to advantage this method is considered to be timesaving and cheaper than hand methods. Another type of puller is the vertical derrick, which has the advantage of applying the pull in the best direction for stumps having long tap roots, but it is objected to on account of having to be moved for each stump.

It is evident that the method to be used should be governed by the character of stumps, the number on a given area, and also by the value of the land, more costly methods being justified for very valuable lands. Mr. Thompson gives in a table several instances of clearing costing $200 per acre, observing that only very rich land or that near centers of population will bear such a tax. The contrast between this figure and that of $8 per acre reported in the Mississippi bulletin serves to illustrate the wide range of conditions.

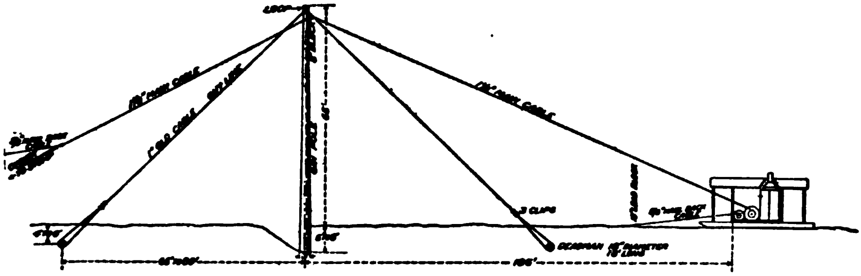

FIG. 4.—Method of setting donkey engine and gin pole in clearing land.

TOBACCO IMPROVEMENT WORK.[a]

In crop-improvement work tobacco is probably receiving fully as much attention as any of the cereals. The problem is approached from the plant-breeding as well as from the cultural side, and some of the results recently secured along both of these lines at several of the experiment stations in tobacco-growing States are here reviewed.

SHELTER-GROWN SUMATRA LEAF.

The Pennsylvania Experiment Station, at the request of the Lancaster County Tobacco Growers' Society, conducted experiments to determine whether by the aid of shelter tents wrapper leaf of the Sumatra type could be profitably produced in Pennsylvania. The earlier experiments showed that a thinner leaf was secured upon the light Penn sandy loam than upon the Norfolk gravelly loam, and that the leaf produced exhibited some defect in elasticity and burning quality, but possessed such good features as large covering power, fineness of vein, and good luster. The experiments were therefore continued to ascertain the influence of seasonal differences, the possibility of reducing the defects observed by modifying the selection and culture of the plants, and to determine the cost of producing such leaf. Accordingly, in 1905, one-sixth of an acre was grown under shelter at Milton Grove. Some of the ground had grown tobacco in 1903 and 1904, while part of it had produced wheat in 1903 and tobacco in 1904. The land was fertilized at the following rate per acre: Cotton-seed meal 1,350 pounds, carbonate of potash 200 pounds, dissolved South Carolina rock 700 pounds, a total of 2,250 pounds. The tobacco was transplanted to the shelter June 5 and 8, the fertilizer was spread broadcast and harrowed in June 25, the first suckering was performed July 17, some of the plants were ready for topping August 2, the ground leaves were ripe for picking August 9, while the main crop was not sufficiently ripe for priming until September 9, or 109 days from planting. On July 20 it was observed that the plants, all produced from selected seed, showed a great variety of form. The leaves of some of the plants resembled the Connecticut seed-leaf variety instead of following the Sumatra type.

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[a] Compiled from Pennsylvania Sta. Bul. 89; Virginia Sta. Bul. 175; Wisconsin Sta. Bul. 176. See also U. S. Dept. Agr., Bureau of Plant Industry Bul. 138; Yearbook 1908, p. 403.

The cost of the repairs to the shelter tent during the season amounted to $10.43, or $62.58 per acre. The expenditures for the production of the crop, exclusive of depreciation of shelter, cost of lath and cases, and the curing, taking down, sweating, and assorting of the leaf, amounted to $95.62.

At Cocalico, where a similar experiment was conducted, the expenditures amounted to $156.75, which is regarded as more nearly representing the probable cost of producing tobacco of this type under shelter than the expenditures made at Milton Grove. Here, as in the other tests, the plants also showed a great diversity in leaf form. This was especially true of the plants grown from the Connecticut Sumatra seed, while the plants produced at Cocalico the previous year exhibited a higher quality. In general the plants from commercial seed showed great diversity of type, while those from self-fertilized seed grown in Pennsylvania in 1904 showed a marked uniformity. Crops of cured leaf weighing 1,200 and 1,700 pounds per acre were secured at Milton Grove and Cocalico, respectively.

Sweating and assorting caused a loss of 21.7 per cent. The tobacco was bulked February 16, 1906, and the temperature rose from 70° F., at that time to 100° on February 25, and fell back to 96° on March 2. The bulk was turned March 3, and on the following day the temperature was 84°, on the 12th 100°, and on the 17th 92°. After thirty days from February 16 the bulk was taken up and assorted.

The cured leaf consisted of about 75 per cent of wrappers and 25 per cent of seconds. Forty-five per cent of the wrappers were light, 30 per cent medium, and 25 per cent dark. Sixty per cent of the leaves were over 16 inches long. In capacity, life, and burning quality the crop of 1905 was superior to that of 1904 and showed a general rating above all domestic Sumatra type tobacco, except the better Georgia and Florida grades. The cured leaf was produced at Cocalico at a cost of 45 cents per pound, and it is believed that the cost of producing the sweated and assorted leaf should not be over 65 to 70 cents per pound. It is stated that the yield per acre may reach as high as 1,600 to 1,700 pounds of cured leaf, and that under these conditions and with the present market prices the application of skill and enterprise to the culture of this crop should result in profit. It is believed that the chances for success are conditioned by the rapid development of the Florida culture of Sumatra type shelter-grown leaf and upon the conduct of the business with sufficient capital to procure the necessary skilled help and to make the requisite fixed investment.

CULTURE OF DARK TOBACCO.

The Virginia Station has reported results with experiments in crop rotation and fertilization, carried on in cooperation with this Department. A crop rotation for the dark-tobacco belt of the State as suggested is based upon tobacco as the leading crop, being followed by wheat, which in turn gives place to grass. After the grass crop corn is grown, which is followed by cowpeas. This rotation may be made to cover a period of five or six years by leaving the land in grass either one or two years.

At Appomattox, where this work is in progress, a plat without fertilizer yielded 810 pounds of tobacco per acre, valued at $56.19; a plat fertilized with 800 pounds per acre of the common 3–8–3 fertilizer yielded 1,070 pounds per acre, valued at $82.18; a plat fertilized with 500 pounds per acre of nitrate of soda yielded 1,280 pounds per acre, worth $93.20; a plat receiving per acre ground fish 1,000 pounds, nitrate of soda 150 pounds, acid phosphate 200 pounds, bone meal 100 pounds, sulphate of potash 200 pounds, costing $32, yielded 1,650 pounds per acre, valued at $154.37.

In 1906 wheat, after a highly fertilized crop of tobacco, yielded 21 bushels to the acre, while after tobacco fertilized with 400 pounds of 3–8–3 fertilizer only 8 bushels were secured. In 1907 the yield of wheat after the crop of tobacco having received the heavy mixed application was 29 bushels per acre, and after a crop which had received only 400 pounds per acre of the usual 3–8–3 fertilizer 12 bushels per acre. No fertilizer was applied to the wheat except that the fields were limed for the benefit of the succeeding grasses.

In 1906 the wheat stubble was disked during the summer and a heavy seeding of grass sown September 3. One part of the field received a mixture of timothy, redtop, and clover, and another clover alone. On April 5 a top-dressing of 300 pounds of nitrate of soda per acre was applied just before a rain. Where the nitrate was used on the clover the yield of field-cured hay was 2.8 tons, and where it was not used 2.09 tons per acre. The increase in yield failed to pay for the nitrate applied on each acre by $1.61. The mixed grasses receiving nitrate gave a yield of 5.06 tons per acre of first-class hay, while where the nitrate was not used the yield was only 3.3 tons. The hay was sold for $13 per ton, so that the gain from the use of the nitrate was $22.88 per acre, the cost of the nitrate being $8.

The successful points with grass in the dark tobacco district, as indicated by this work, are a fine mellow seed bed 2 or 3 inches deep, a heavy seeding of mixed grasses, and a liberal top-dressing of nitrate of soda in the spring, preferably just before a rain. It is estimated that under the rotation practiced the first year from 1,200 to 1,500 pounds of tobacco may be secured with a heavy application of fertilizer; the second year from 20 to 30 bushels per acre of wheat without the use of fertilizer; the third and fourth year from 2 to 3 tons per acre of hay from mixed grasses, providing a liberal application of nitrate of soda is made as a top-dressing early in the spring; the fifth year from 40 to 60 bushels of corn per acre, receiving barnyard manure and a commercial fertilizer applied with a drill; and the sixth year 1 ton or more of cowpea hay per acre, with the crop fertilized with a little acid phosphate and sulphate of potash.

TOBACCO-SEED IMPROVEMENT.

The Wisconsin Station for several years has carried on tobacco improvement through seed selection. The quality and size of the leaf grown in the State was unsatisfactory to the manufacturers, and after a conference with buyers and growers it was decided that a type of Connecticut Havana, Wisconsin grown, would best meet the requirements of the farmer, the buyer, and the manufacturer. Accordingly, seed of this type was secured and 1 acre of land was planted for seed. More than one-half of the resulting plants were not true to type and about two-thirds of the original number of plants were culled out, leaving only those showing the most desirable type to grow and produce seed. The belief is expressed that tobacco is as susceptible to improvement as any farm crop, and that the value of the Wisconsin crop can be increased from 20 to 30 per cent by the continuous selection of tobacco seed alone. It is pointed out that in the selection of individual plants for seed production the following points should be borne in mind: (1) Vigor of the plant, (2) spread and shape of the leaves, (3) number and arrangement of the leaves on the stalk, (4) prominence of the midrib, (5) texture and thinness of the leaves, (6) liability to produce suckers, (7) color of the leaves, and (8) attachment of the leaves to the stem. The points of a good seed plant are given as follows:

> A typical plant should have a medium to stout stalk so as to be able to uphold the plant during windy weather. The leaves should be arranged compactly on the stalk and should grow close to the stalk. The leaves should be broad; in fact, the broader and more rounded the leaf is, the more valuable it is, since a larger number of binders or wrappers can be cut from it. Plants showing prominent ribs should not be saved for seed, as these are objectionable to the cigar manufacturers. Texture and quality are difficult to describe, but in general the leaves should be thin and elastic; that is to say, a cured leaf should possess flexibility and elasticity. The leaves, for this reason, should have a certain amount of gum or oil. Quality is greatly influenced by fertility and character of the soil. Considerable improvement along this line can be obtained through careful seed selection. The leaves should have little or no leaf stalk and they should not be tapering from the stem end, but should expand directly from the stalk.

When the plants are ready to flower all side shoots are removed so that only the early central flower clusters are left to produce the seed, the main object being to throw all the energy of the plant into the production of the seed from the central stalks. It is advised that topping be done early enough to prevent the expansion of any flowers, as these are very likely to cross-fertilize the blossoms of plants intended for seed. Stripping seed plants is considered bad practice, inasmuch as the leaves are necessary for the full development of strong and large seed. When the seed is ripe and before frost appears the stalks should be cut off a foot or more below the seed pods and hung in a dry, well-ventilated place to promote uninterrupted curing. This will require about two months, when they can be taken down and the seed shelled out on canvas with an ordinary hand flail. This is readily accomplished if done during dry weather. By means of tobacco seed cleaners or ordinary fine hand sieves all small and light seed should be removed, so that only the plump and strong seeds are left for planting.

Ordinary commercial tobacco seed has a germination of 40 to 60 per cent, while really first-class seed should test about 90 per cent. If only the strongest and most vigorous seed is used the young plants will show vigor and endurance in the seed bed. The seed after cleaning should be stored in a dry place and may be kept for several years without much deterioration. A simple way of testing tobacco seed is described as follows:

> Secure two pieces of heavy white blotting paper about the size of an ordinary saucer. Moisten these to saturation with as much water as they will hold without dripping. Count out 100 average seeds as they come from the seed bag, and place these on one of the blotters which has previously been placed in a saucer. The seed should be

separated so that they will not come in contact with each other. Then place the other blotter over the seed, and finally invert another saucer over the blotters. The tester should be kept in a warm place having a uniform temperature from 65° to 75° F. At the end of ten days open the tester and count the seeds which have sprouted. Care should be taken in removing the top blotter so as not to spill any of the seeds as they may adhere to its surface. After counting the percentage of germination, the remaining seeds should be left for a few days longer and again counted. The number obtained from the two countings is the percentage of germination. The tester should be examined daily to see if the blotters are drying out; if they are, small quantities of water should be introduced at the edges of the blotter.

Much stress is laid on the selection of the plants in the seed bed, as this is regarded as really the starting point. The ordinary practice of taking the plants from the seed bed at three or four different times as they grow large enough is not recommended. The first plants are the strongest and most vigorous, and hence the best to plant.

CALF FEEDING.[a]

The question of substitutes for whole milk for feeding calves is one that is of much importance, especially to dairy farmers. In cases where skim milk is available it becomes a question of substitutes for the butter fat that has been taken out of the whole milk. The availability of various substitutes that have been found fairly satisfactory depends on the purpose for which calves are intended. If calves are intended for veal, then it is desirable to feed to obtain as large a gain in weight with as good appearance as possible in the shortest possible time; if the intention is to raise the calves to maturity, it is desirable to bring them to the point where they can take care of themselves, that is, where they have learned to eat and digest coarse feed in quantity sufficient to maintain satisfactory growth with the least possible expense and labor.

Some years ago a number of the stations studied the question of substitutes for the butter fat taken out of whole milk and reached conclusions, agreeing in the main, in favor of some sort of a grain ration to supplement the skim milk. These conclusions have been noted in previous bulletins of this series.[b] With the increasing prices of grain the possibility of finding a cheaper substitute seems extremely desirable.

The Louisiana Station conducted an experiment "to determine whether or not low-grade sugar-cane molasses (blackstrap) could be used as a supplement to skim milk * * * for calf-feeding purposes."

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[a] Compiled from Illinois Sta. Circ. 118; Louisiana Stas. Bul. 104; Massachusetts Sta. Rpt. 1908, p. 103; New York Cornell Sta. Bul. 269; North Carolina Sta. Bul. 199; Virginia Sta. Bul. 172; Ontario Agl. Col. and Expt. Farm Rpt. 1903, pp. 73, 74.

[b] U. S. Dept. Agr., Farmers' Buls. 84, p. 20; 92, p. 21; 233, p. 22.

The following conclusions were reached:

On account of its laxative effect, "blackstrap" molasses can not be used as a supplement to skim milk for calf-feeding purposes in sufficient quantity to be of any practical value.

This laxative effect is due to the sugar content, rather than to any of the other constituents of the "blackstrap."

Scouring is caused by the fermentation of the sugar in the digestive tract.

Salt and tannin have a beneficial effect, but will not prevent scouring.

The same station also reports a method of feeding calves in which milk is dispensed with entirely after the first few days.

The calves are taken from their dams a day or two after birth and taught to drink from a pail. They are then given 5 to 8 pounds of their mother's milk twice a day until the milk is fit for human use, which of course will vary with the different cows, but on the average * * * the milk [may be saved] on the fifth day after calving. The milk is then reduced until at the end of ten days the calf is receiving 1 pint of milk twice a day, and this amount of milk is fed until the calf is 6 weeks of age, when the milk is discontinued entirely. At the same time that the milk is being reduced, bean soup, shorts, blood meal, and sometimes cotton-seed meal are added to the calf's ration until at the end of ten days it is receiving twice daily, in addition to its pint of milk, bean soup from 4 ounces of navy beans, 3 ounces shorts, 1 ounce blood meal, and probably about half the time 3 ounces of cotton-seed meal. The calf receives this ration until it is 6 weeks of age, when the milk is discontinued and the same amount of the substitute fed as before until the calf is 4 months old, when it is weaned; that is, put on dry feed entirely. The calf is encouraged to eat hay as soon as it will.

Alfalfa hay is preferred, with peavine hay as second choice, and calves "have access to grass whenever there is any."

It is thought that failures in the use of this plan are due to faulty preparation of the bean soup, and the following method is recommended as likely to give success:

Parboil the beans in soda, then drain off the water and boil again until soft. Squeeze through a colander and add salt until the soup has a decidedly brackish taste. Stir in the shorts, blood meal, and cotton-seed meal and add lukewarm water until each calf receives about 3 quarts of the mixture. Of course the amounts to be given will vary with different calves. The above figures are the average for strong grade Holstein calves. The cost of the milk substitute is between 4 and 5 cents per day.

The Virginia Station has carried on feeding trials designed to compare the value of different grains as a supplement to skim milk.

The grains used in this trial were: Shelled corn, shelled corn and bran, 4 parts of the former to 1 of the latter by weight; corn meal and bran in the same proportion, and cracked barley and bran also in the same proportion. Shelled corn is probably the most available grain for calf feeding, and it seemed desirable to secure some data as to its value in supplementing skim milk, as compared with a combination of shelled corn and wheat bran. Wheat bran has become so expensive in the last few years that it is advisable to substitute a cheaper foodstuff as far as possible. It was also thought desirable to secure a comparison of the whole grain with the same grain in the form of meal. Barley has not been raised or fed very extensively in the South, but on land suitable to its growth it gives a good yield and is a very valuable foodstuff.

Six groups of four calves each were used, groups 1 to 4 being dairy bred and the other two of beef breeds, and the groups were made as nearly uniform as possible.

The method of feeding was as follows:

> The calves were confined in stanchions * * * while the skim milk and grain were fed; after this they were allowed the run of the barn with access to the hay rack at all times. The skim milk was fed first, in round-bottomed buckets, and immediately afterwards the grain; the grain and skim milk were never mixed together. It is important that the milk and grain be fed separately, as it is much better masticated, and the digestive juices have a much better chance to do their work. It is probable that some of the failures in feeding calves on skim milk are due to mixing grains that do not go into solution with the milk. The calves were fed for the first week on whole milk, then the skim milk was gradually substituted for it. They would usually begin to eat the grain and hay at 10 to 12 days old. It was found that the calves learned to eat the ration containing bran somewhat quicker than they did that of shelled corn alone. Care was taken that the skim milk be fed fresh. A small hand separator was used at the barn, and the milk was taken directly from the cow to the separator, and fed in a very short time after separating. It was found that when handled in this way, only in the very coldest weather was it necessary to use any artificial heat.

The calves were fastened at feeding time to save the time of the feeder and to keep them from each other until their noses were dry, and also because it was found that they learned to eat more readily in this way.

> The following rules were observed in feeding the calves and were found quite satisfactory: Ten pounds of milk for the first 100 pounds of live weight, 5 pounds of milk for the second 100 pounds of live weight, and 2.5 pounds of milk for the third 100 pounds of live weight. Until the calf was 3 months old 1 pound of grain to 10 pounds of milk was fed. From 3 to 6 months old 1 pound of grain to 5 pounds of milk was fed. * * *
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> The grain consumed per day varied from 2.04 pounds with the group receiving shelled corn and bran to 2.25 with the group receiving shelled corn alone. [The] group which received shelled corn and bran consumed the smallest amount of skim milk, while [the] group which was fed barley and bran consumed the highest amount. There was slightly more variation in the amount of hay than of grain. The amount of grain per pound of gain only varied 0.09 of a pound. It is evident from this that there is no practical difference in the amount of grain required per pound of gain. A gallon of skim milk for each pound of gain was consumed. * * *
>
> Bran was used to great advantage in teaching the calves to eat grain, but no advantage was secured from adding bran to a ration of shelled corn to supplement the skim milk, either in rate of gain or the appearance of the calf. The best results were obtained from shelled corn. The calves did not consume as much corn meal per day as shelled corn, nor did they make as large a rate of gain. It did not require as much shelled corn as corn meal per pound of gain. Barley was found to be an excellent grain to supplement skim milk, but owing to the high market price of the barley as compared with corn it did not show as good returns financially. However, it must be borne in mind that barley can be produced pound for pound as cheaply as the corn. * * *
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> The importance of hay for young calves can not be emphasized too strongly; they should have access to good, clean hay at all times.

The cost per day varied from 5.4 cents to 6 cents; or from about $1.60 to $1.80 per month. The cost per pound of gain was lowest with the beef-bred calves receiving shelled corn and bran, 3.29 cents; and highest with the dairy-bred calves receiving barley, 4 cents.

The increase in weight per head per day with the dairy-bred calves varied from 1.42 pounds with those receiving corn meal to 1.60 pounds with those receiving shelled corn. The increase per head per day was 0.2 greater with the beef-bred calves than with the dairy-bred calves receiving the same ration.

The group of calves fed whole milk made the largest gain, but at the highest cost per day and per pound of gain. They presented a better appearance before weaning, but at 8 months of age there was little difference either in weight or appearance between those developed on whole milk and those on skim milk.

The formaldehyde treatment[a] for scours has been used with great success, not only with the calves in this experiment, but with a large number of others.

In raising calves to keep up a dairy herd the cost may run higher, as the number to be fed would be limited to the best individual offspring of the highest income-producing cows and would therefore vary from year to year and would never be a large number. Then, too, it must be remembered that the value of such calves is to be calculated on what they will produce when they become cows.

The Massachusetts Station reports that the one or two calves raised yearly to keep up the dairy herd cost, for feed, from $40 to $45 up to the time they are 2 years old. They are pastured in summer and in winter fed hay, silage, and 2 or 3 pounds daily of a mixture of bran and fine middlings.

In a circular of the Illinois Station, W. J. Fraser gives the results of some experiments carried on at that station to determine whether or not it was true, as some dairymen had said, that raising their own stock is not worth while.

Twelve calves at a time were tested at four different times. It was found they could be successfully raised on 150 pounds of whole milk and 400 pounds of skim milk. This milk was fed at the rate of 10 pounds per day until the calves were 50 days old, when it was gradually lessened 1 pound per day for 10 days, and then no more was fed. No substitutes for milk were used. Only ordinary grains which the farmer produces, and a good quality of legume hay were fed, showing that the dairymen can raise a calf in this way with almost no extra trouble. Several of these calves are now cows in milk and good producers, indicating that they were not injured by this method of raising.

The sale value of the milk fed these calves was as follows:

150 pounds whole milk, at $1 per 100	$1.50
400 pounds skim milk, at 30 cents per 100	1.20
Total	2.70

And these prices of milk are liberal, especially as they are paid at the farm, and no money or labor is expended in hauling the milk to market. It is not so expensive to raise a calf as the dairymen have thought. The grain and hay consumed by the heifers of high quality will give much better returns than the same feed fed to cows.

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[a] U. S. Dept. Agr., Farmers' Bul. 273, p. 17.

A prominent and successful dairyman of the State says that he can raise a heifer to the age of 2 years at a cost of $20, including the value of the calf at birth, and he has been offered $50 for some of his heifers at that age.

Another dairyman who has successfully managed a large herd of cows for several years estimates that it costs about $18 a year to raise the average calf.

But even allowing $40 to raise a heifer to the age when she begins to give milk, she will then be the equal of cows that could be bought for $60. Here is a clear advantage of $20 per cow in raising over buying, but the actual added profit in the life of the home-raised and well-raised cow is more apt to be two or three times this amount. * * *

Another great advantage in raising the heifers is that the owner may feed his calves in the correct manner to develop them to their greatest capacity. Cows that have been properly raised are much more efficient, and therefore worth more than if they had not been so raised.

John Michels experimented at the North Carolina Station with rolled oats as a partial substitute for milk in calf feeding with especial reference to the needs of dairymen who have little or no skim milk.

The rolled oats were prepared by adding boiling water to them at the rate of 1 gallon of water to 12 ounces of rolled oats, and the mixture was then allowed to stand until cool enough to feed. * * *

The daily allowance per calf during the thirteen weeks of the experiment was as follows:

First week—10 pounds whole milk.
Second week—8 pounds whole milk, 4 ounces rolled oats.
Third week—6 pounds whole milk, 8 ounces rolled oats.
Fourth week—4 pounds whole milk, 12 ounces rolled oats.
Fifth week—2 pounds whole milk, 12 ounces rolled oats, 0.2 pound grain mixture.
Sixth week—2 pounds whole milk, 12 ounces rolled oats, 0.4 pound grain mixture.
Seventh week—2 pounds whole milk, 12 ounces rolled oats, 0.6 pound grain mixture.
Eighth week—2 pounds whole milk, 12 ounces rolled oats, 0.8 pound grain mixture.
Ninth week—2 pounds whole milk, 12 ounces rolled oats, 1.0 pound grain mixture.
Tenth week—12 ounces rolled oats, 1.0 pound grain mixture.
Eleventh week—12 ounces rolled oats, 1.0 pound grain mixture.
Twelfth week—12 ounces rolled oats, 1.2 pounds grain mixture.
Thirteenth week—12 ounces rolled oats, 1.2 pounds grain mixture.

The grain mixture consisted of one part each of corn meal, linseed meal, and wheat bran.

The milk was always added to the oat preparation just previous to feeding.

In addition to the above feeds, the calves received all the hay they would eat during the winter, while in spring they received one feed of hay with pasturage additional.

On the basis that 1 pound of rolled oats is equal to 1 gallon of whole milk, and that whole milk is worth 8 cents per quart to milkmen, the cost of the milk for a 13-weeks-old calf receiving no rolled oats is $26.96. When rolled oats (which cost 4.4 cents per pound delivered in barrel lots) are substituted for milk as shown above, the cost of the calf feed for the same period is only $12.46, a saving of $14.50 in favor of the rolled oats. * * *

One thing that especially commended itself in the rolled-oats feeding was the evident relish with which the calves devoured them. The extra labor entailed in the feeding of the rolled oats was insignificant as compared with the saving effected.

One precaution to observe in feeding rolled oats to calves is not to use it in too large quantities, owing to the laxative character of this feed. Indeed, our experience indicates that it is best not to feed more than 12 ounces daily to each calf. It is important also that the rolled oats and milk be supplied as near the temperature of blood heat as possible.

The average gains made were slightly better for the calves fed rolled oats than for the calves fed skim milk, and good development was shown.

The New York Cornell Station conducted experiments with three lots of calves in 1907–8 and with four lots in 1908–9, with a view to finding a satisfactory substitute for skim milk.

The feeds compared were skim milk, skim-milk powder, and three commercial calf meals. The calves were fed all the dry grain they would eat up clean. This grain was a mixture made up as follows: 6 pounds of corn and oats, ground half and half by weight; 3 pounds of wheat bran; and 1 pound of oil meal. The cost of the mixture was $29.55 per ton. A mixed hay, with a good percentage of clover, was kept before the calves at all times.

It was found that a tablespoonful of soluble blood meal mixed with each feed kept the bowels of the calves in good condition at a small expense.

Only one of the commercial calf meals used gave satisfactory results from the standpoint of cost, and even that gave an average cost per pound of gain of 8 to 9 cents.

The results for the two years are summarized, in part, as follows:

> (1) It is evident from the results of these experiments and those elsewhere that good, strong, healthy calves can be raised without skimmed milk or milk of any kind after the first thirty days.
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> (2) Skimmed milk, hay, and grain make the best substitute for whole milk in raising calves. A calf fed on skimmed milk should reach a weight of 300 pounds at five months of age, and the gain should be made at the rate of 1½ pounds per day, at a cost of less than 5 cents per pound.
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> (3) If skimmed milk is not at hand, the best substitute for it seems to be third-grade dried skimmed-milk powder. The average gains made in this experiment were not so large as with the skimmed milk, but were good. A calf fed on this food should reach a weight of 250 to 260 pounds at five months of age, making an average gain of 1.25 pounds per day at a cost of less than 6½ cents per pound.

Professor Dean, of the Ontario Agricultural College, tried a decoction of cocoa shells as a substitute for skim milk and obtained satisfactory results; 0.25 pound of the cocoa shells was boiled in 2 gallons of water and 1.5 to 2 gallons of the decoction were fed daily together with some grain and green feed. While the gains were not as large as with skim milk, the conclusion was drawn that this decoction "appears to be a very good substitute for skim milk and is worthy of a trial by those farmers who wish to rear calves and have little or no skim milk to feed."

The subject of artificial feeds for calves has been and still is being studied by many foreign investigators.

Cod-liver oil has been fed successfully as a substitute for the butter fat taken out by the separator, according to reports of Scotch and Irish experiments; it was fed at the rate of 2 ounces to 10 pounds of separator milk. It was found that the calves fed this combination did not gain quite as much as those fed whole milk up to the time of weaning, but after that the oil-fed calves made greater gains than the others. The cost of the combination ration was about half that of whole milk.

A recent Brazilian report gives the result of the feeding of 6 calves from birth to the age of 6 months. The calves were of European breeds and received especial care, since it is desired to establish a herd adapted to the climate of Brazil. The calves were taken at once from their dams and fed from a pint to a pint and a half of milk four times a day, each calf receiving the milk from its own dam. After the first week milk from the herd was fed. Four feedings a day were given for three weeks, and then 3 feedings till the end of the third month. The calves were weighed every week and the feedings increased in accordance with gain in weight. Gains averaged 1¾ pounds daily and were extremely uniform throughout the period. At the end of the second month the whole milk began to be replaced by skim milk, to every quart of which was added about 3½ ounces of either corn meal, cassava meal, or good wheat bran. The whole milk was gradually replaced, until at the end of the third month no whole milk was fed. It should be understood that the periods of time given are not exact, but varied slightly according to the progress and needs of the individual calf. A little grass and hay was fed from the beginning of the third month and gradually increased. Little trouble was had with scouring, and it was readily controlled by giving on two successive days one-half ounce of sulphate of soda, followed on the third day by 15 grains of salol.

In Italy the experimental work reported has been mostly along the line of trying various supplements to skim milk, especially for veal. A recent report compares the results of feeding 6 groups of 4 calves each. One group was fed whole milk, the other 5 groups were fed skim milk with the following additions: Rice flour, corn meal, starch, oleomargarine, and whole milk. For the 5 groups there were 3 feeding periods. The first began at birth and lasted from eighteen to twenty-five days, according to the progress and condition of the individual calf. During this period whole milk was fed. The second period was a transition period, in which the whole milk was replaced by skim milk and the various supplements at the rate of a quart a day. The third period lasted from thirty to forty-eight days, and during this period no whole milk was fed. In the first period the calves were fed three times daily, in the other two periods only twice, the midday meal being gradually decreased, and finally omitted. The rice flour and the corn meal were mixed with part of the skim milk and added to the remainder just as it came to the boiling point. The mixture was then boiled about fifteen minutes, being stirred constantly to prevent lumping or sticking to the vessel. The starch was made into a thin paste with cold milk and then added to the rest of the milk when it was at about 145° F., and the mixture slowly raised to the boiling point, then quickly removed from fire. In case the mixture was too thick it was cooled quickly by placing the vessel in cold water. The oleomargarine was added to the skim milk by means of a commercial emulsion. The proportion of skim milk to whole milk in the case of the fifth group was 1:1 and 2:1. The temperature of feedings was about 94° F. The starch was fed in the proportion by weight of from 3 to 5 parts to 100 parts of skim milk. The rice flour was added in the proportion of 5 to 9 parts to 100 parts of skim milk. It was found that the lower proportion gave satisfactory results, but more than that produced serious digestive disturbance. The proportion of corn meal to skim milk was 5–6:100 and of oleomargarine 2–3:100. During the last period salt was given with each feeding at the rate of 0.3 ounce per 100 pounds of live weight. The amounts fed were determined by the condition and progress of each animal, and varied from one-tenth to one-sixth of the live weight.

The conclusions reached may be summarized as follows: All the groups gave satisfactory financial returns. The smallest return for the skim milk fed was 73 cents per 100 pounds and the largest $1.39 per 100 pounds, while the average ranged from 87 cents to $1.16 per 100 pounds.

The groups fed corn meal and starch kept in the best condition, while the meat of the starch-fed group was slightly superior to that of any other of the artificially-fed groups. The condition of the group fed oleomargarine was next, and that of the group fed rice flour was poorest. As for the two groups fed whole milk and a mixture of whole milk and skim milk, both groups kept in excellent condition, but the meat of the group fed whole milk was fatter.

The same investigator later conducted a similar test under conditions more nearly like those that would obtain in ordinary farm practice. The results were satisfactory but the returns were somewhat smaller, the lowest return for the skim milk fed being 64 cents per 100 pounds and the highest $1.34 per 100 pounds.

In Austria considerable study of different phases of the calf-feeding problem is reported. One writer lays especial stress on the necessity of letting calves run in a good pasture when they are to be raised to replenish herds. This seems especially necessary for high-bred stock in order that a good foundation of health may be laid.

Another report says that a 3½ per cent emulsion of palm oil may be profitably used as a substitute for the butter fat taken from whole milk. Figures are given showing a saving of 1⅓ cents per quart of whole milk after allowing for labor and depreciation of machine. This method involves considerable labor as well as an emulsifying machine, so that it would doubtless be practicable only on a large scale.

Numerous German experiments in artificial calf feeding have been reported. Homogenized milk is said to be valuable for feeding calves, owing to its digestibility, but it would seem available only when there is no convenient market for butter fat. Linseed-oil cake has been found of value as an addition to skim milk, as it is reasonable in price and has a good effect on the digestion.

One experiment reported was a comparison of whole milk, skim milk, and skim milk with the addition of peanut oil or flaxseed or starch. It was found that skim milk gave as much increase in body weight as whole milk, but the valuable digestive qualities due to the fat in whole milk were lacking. Flaxseed as a substitute for the fat of whole milk gave the best results both in increase of body weight and in digestibility. It is prepared by thorough soaking in hot water. About one-third of a pound is given at a feeding. Peanut oil in emulsion worked well but not in too large doses. Equal parts of peanut oil and warm water and a small amount of a commercial emulsive preparation were shaken until thoroughly mixed, and of this emulsion not over two-fifths of a pint was given at a feeding. Starch paste made as previously described did not help the digestive disturbances caused by skim milk. About one-fourth of a pound was the quantity given at a feeding.

There are numerous reports on the value as an addition to skim milk of starch inverted with diastasolin; this is a commercial preparation made from malt which has the property of transforming starch into dextrin and then into sugar, thereby increasing the digestibility of the starch. A pound of starch is mixed with a quart of cold water and the mixture is slowly added to 3½ quarts of boiling water, thus forming a thick paste which must be stirred constantly to prevent lumpiness. After the paste has cooled to 110° F., about two-thirds of an ounce of diastasolin is added, dissolved in a little lukewarm water. The thick paste becomes thin through the action of the diastasolin in about half an hour. Of this mixture about 1⅓ ounces to a quart of skim milk is fed. Good results are reported from the use of this mixture, but it is laxative in effect and care must be taken not to give too much of it. This mixture may be prepared in quantity sufficient to last three days in winter, but in summer it must be prepared every day.

An English writer states that calves raised on whole milk for veal should not be kept as a rule more than a month and should be fed three times daily. It is noted that boxes in which calves are kept should be light and well ventilated. Unless the very highest prices are obtained for veal it is not found profitable to feed whole milk.

In France experiments are being made all the time with various supplements to skim milk. Many of these are the same as those already mentioned. There is some discussion as to the value of pasteurization in connection with calf feeding, but it would seem that for the small farmer it is not worth while.

It has been found that denatured sugar forms a valuable and economical addition to skim milk for calves. Denatured sugar is sugar to which various ingredients have been added for the purpose of rendering it unfit for human consumption. It is claimed that, contrary to general belief, it does not have an injurious effect on the digestive organs; on the contrary, that its solubility renders it more digestible, and that it has a high food value. The amount fed at first is 1 ounce per quart of skim milk, and it is claimed that it can be fed to calves ten days after birth without danger. At first not over 3½ ounces is given at a feeding, but afterwards the amount may be raised to 1½ ounces per quart of skim milk. Of 2 lots of 4 calves each fed on skim milk supplemented by starch and denatured sugar, the respective profits averaged $13.24 per calf in the lot fed sugar and $6.12 in the lot fed starch. The calves were kept an average of ninety-five days.

In conclusion attention may be called to a few important points: In selecting a supplement to skim milk the farmer will have to be governed by local conditions; that is, use what is most available. It must be remembered that most of the supplements require considerable labor for their preparation. Great care must be used in adapting the artificial ration to individual calves. In this connection it should be remembered that it is very desirable to feed calves separately. Finally, it seems to be well established that for the production of absolutely first-grade veal nothing will take the place of whole milk, but to justify its use fancy prices must be obtained for the product.

GASOLINE-HEATED COLONY BROODERS.[a]

The use of gasoline to develop heat for brooders has been worked out with a great deal of care at the New York Cornell Station, and has many points to commend it to those who raise poultry on a fairly large scale; the system involves broods of 200 chicks, so that it is not suitable for those who have only small hatches.

The principal advantages in using gasoline rather than kerosene are to secure a higher temperature when needed without forcing the heater and to save time and labor by having one brooder house serve for 200 chicks instead of 50. The form of house used is what is called the "A" type (fig. 5) and is constructed as follows:

---

[a] Compiled from New York Cornell Sta. Bul. 248.

The "A" type of house is 8 feet square, inside floor measure, has 12-inch side walls and is 6 feet 6 inches from top of floor to top of ridge board. The subframing is made and both floors laid before the upper part of the building is put together. The sills are gotten out first. They are made of 2 by 12 inch stock and are cut 8 feet long, with a bevel at each end to form runners or shoes upon which to draw the house about when desired.

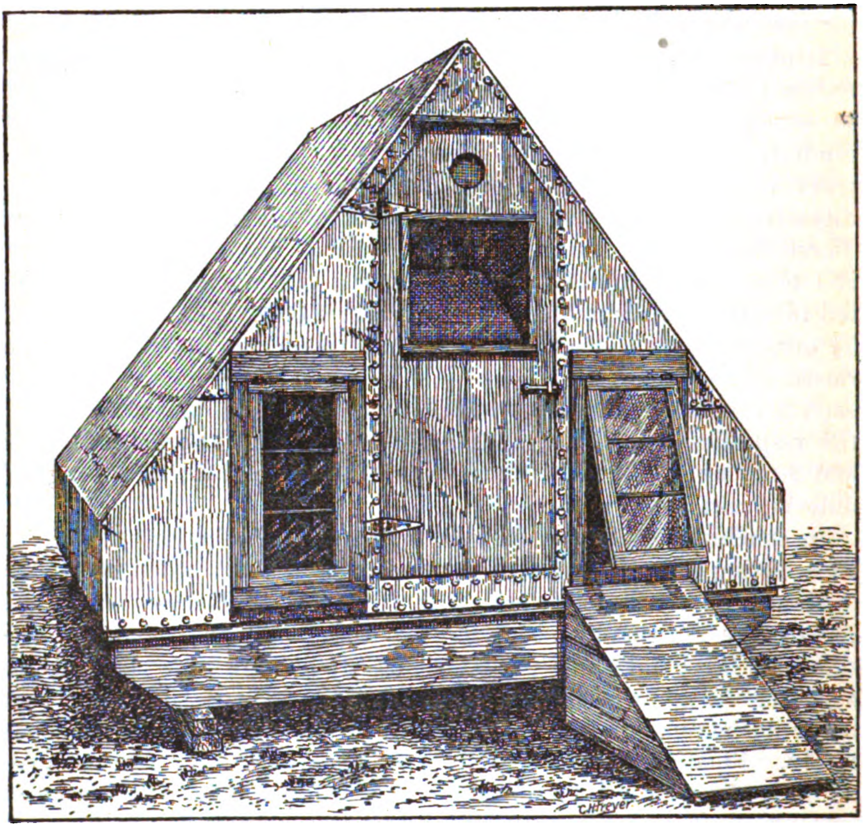

FIG. 5.—"A" type of colony brooder house.

An opening of 8⅜ inches by 12 3/16 inches is cut in the rear runner to admit the burner box. The top of this opening is 1¼ inches from the top of the runner and has a ¼-inch slit sawed into the runner horizontally from the two upper corners for the purpose of admitting the flange, or projection, of the upper edge of the burner box. A piece is cut from the runner directly over the center of this opening to admit the collar, which is on top of the burner box. The piece is sawed out on a miter so that it can be replaced and secured by a single screw. The opening made by removing this piece is 5 inches in the clear.

A strip 1 inch square and 18 inches long is nailed to the inside of the runner 1 inch below the lower edge of the opening, for supporting the rear end of the insulating box.

The floor joists, four in number, are made of 2 by 4 inch stock, cut 8 feet long, and are fitted into the runners with a half joint. This gives a strong subframe that is not likely to get out of square when drawn over uneven ground. After fitting the joists into the runners and securely nailing with 20d. nails, the work is leveled, squared, and tied by means of a 1-inch board nailed diagonally across the joists.

The support for the burner box is then put in. It is made of three pieces of 2 by 4 spiked to the rear runner and to the two center joists. It is placed flush with the top of the joists and runner so that the flooring can be nailed to it. The inside dimensions, 13½ by 24½ inches, are such as to allow the flange of the burner box to slide in easily. The flange rests on ½ by 1 inch strips, which are nailed 1 9/16 inches below the top of the 2 by 4's forming the support. This leaves a space of 1½ inches between the top of the burner box and the floor of the house, which prevents the floor from becoming too warm and serves as a chamber in which to warm the fresh air that is admitted for ventilating the hover. The cool fresh air is taken from beneath the house through four 1-inch holes bored in the 2 by 4 supports. It is warmed by passing over the metal top of the burner box and as it expands is forced upward around the stem and down upon the chicks.

The insulating box is made of ⅞-inch matched pine flooring and is supported at the rear by resting on the strip at the bottom of the runner and in front by hooks and eyes, such as are used for screen doors, to the support.

The first or sub floor is made of 1-inch matched hemlock siding and is laid diagonally, which helps to stiffen the building. The finished floor is made of ⅞-inch sap (white) pine flooring. This is blind-nailed and is laid over a layer of building paper.

The studs are now put up. These, together with the plates, rafters, and ridge board, are made of ⅞ by 2¼ inch clear hemlock stock. The studs are placed flush with the outer edge of the floor and are toe-nailed to it. The plates are laid on and nailed to the ends of the studs. The rafters are first nailed to the ridge board and then put in place and toe-nailed to the plates. These are held in place temporarily by nailing a strip of board diagonally across them. The front and rear studs are fitted in place and then the boarding put on. The boards are put on horizontally and overlap the floor 2 inches.

The building is inclosed with ⅞-inch matched siding, planed one side, with the smooth side turned in. The boards for sides and roof are cut in 8-foot lengths, and since the house is to be 8 feet square inside, a small space is left at each corner which is filled by a quarter-round molding, thus making it possible to use 16-foot stock without waste. The ends are boarded up solid, with the exception of the door opening. After the paper has been put on the casings for the windows are nailed in place and then the openings cut. By this method of construction no studs are required for the windows.

Best results have been secured by running the strips of roofing paper vertically instead of horizontally, as is generally recommended. The laps are made to come over the rafters and are covered with a ¾ by 2 inch batten. It requires much less time to put the paper on in this way and it presents a more pleasing appearance.

After the house is inclosed and doors and windows fitted and hung, the heater is put in place. (Figs. 6 and 7.) To do this a circular opening, 6 inches in diameter, is cut in the floor toward the back of the house. The center of this opening is 19 inches from the back of the house and 4 feet from either side, inside measurement. The chick guard fits into this opening. The burner box is slid in from the back of the house (B B, fig. 8), and the stem telescoped down over the collar. The radiator is secured to the hover and telescopes over the top of the stem. The opening for the vent pipe in the back of the house is located so as to correspond exactly to the vent pipe coming out of the radiator. Great care should be exercised in installing the heater, as any loose fitting connections would cause leakage of gases into the hover.

The hover is made of ⅞-inch matched pine flooring, planed both surfaces, and is held to the back of the house with detachable hinges. It can be raised and held up out of the way with a hook and eye or may be entirely removed while cleaning the floor of the house. The front is supported by two pieces of broomstick serving as legs at each corner. It is inclosed by a double curtain of table oilcloth, unfinished surfaces together, reaching to within 1 inch of the floor. This is made into a fringe by a series of vertical slits 4 inches apart, extending upward 6 inches. The slits in the outer thickness of the curtain are made to break joints with those of the inner. Table oilcloth is used in place of felt or woven cloth because the chicks eat the felt and are likely to become entangled in the ravelings from the woven cloth. It is also easier to keep clean. A hole is bored 4½ inches from the front of the hover and the thermometer inserted so that the bulb is within 3 inches of the floor.

The gasoline tank is put in place by cutting a circular opening 8½ inches in diameter through the rear gable of the house. The inner end of the tank is supported by a piece of 1 by 6 inch board hollowed out to fit the can and fastened to the rafters. (Fig. 6.) It is secured at the rear end by nailing the square galvanized-iron collar to the outside of the house and at the inner end by wiring to the 1 by 6 inch support. The iron piping is now fitted together and the burner connected. All threads are well soaped over with soft soap before screwing together. When the burner is in place it should be so located as to be directly underneath the center of the stem. (Fig. 6.)

Figure 5 shows the colony house completed. * * * The runners, as shown, are 12 inches high and are placed in the front and rear of the house. Runners 6 inches high have been tried with satisfactory results. The runners may be placed on the sides instead of the ends. This is sometimes advisable when the houses are to be used in orchards, because it allows the house to be drawn between the rows of trees with less danger of striking. Whatever the height of the runner, the burner box should be taken out before moving the house. If left in, it might be bent out of shape by striking stones or uneven places in the land. To remove burner box, raise hover, lift out stem, disconnect piping at union coupling, and withdraw box. Care should be taken that the wheel valve next to the tank is closed before disconnecting the pipe and that the lead gasket is not lost out of the union coupling.

The cost of materials for the house at prices prevailing in Ithaca, N. Y., is $22.46. Two days' work by a carpenter is sufficient to build the house. The heater complete costs $10 in Ithaca, N. Y.; it can be made by any good tinsmith from the working plan shown in figure 6, and includes all the metal parts shown in the figure except the filling can and also includes a burner. The form of burner that was found most satisfactory was one that "gives a cone-shaped blaze directed up into the radiator * * * instead of being sent out in jets at right angles to the burner. It gives more complete combustion than the cap type of burner and is capable of a wider range of temperature; that is, it can be turned very low for use in mild weather,

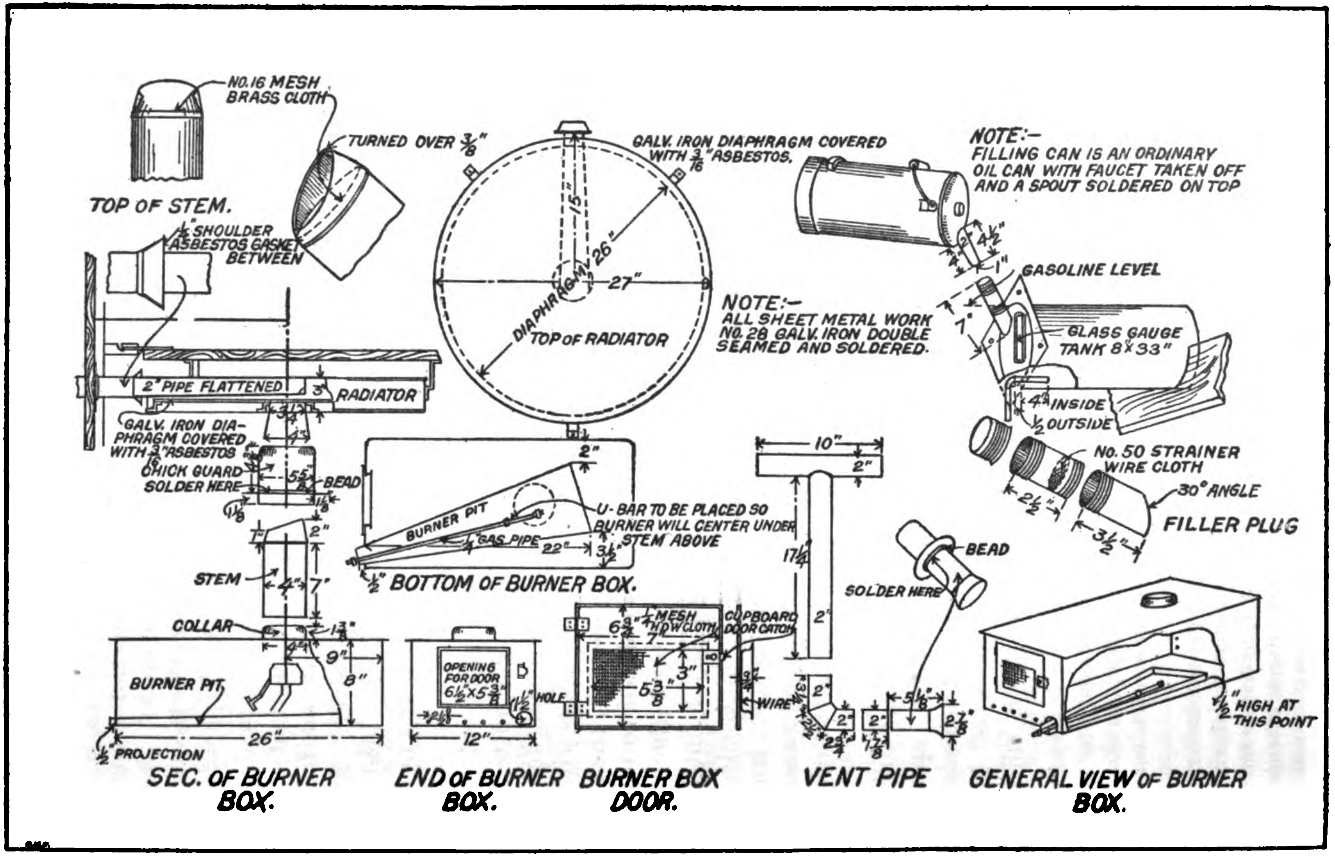

FIG. 6.—Details of construction of heating apparatus for brooder house.

or will give a flame sufficiently large to maintain the proper temperature under the hover when it is 10° to 150° below zero outside." The burner selected should have but one control valve, as it is less complicated and less likely to clog.

Figure 7 represents the heater. The burner box slides under the house through the rear runner as shown at B B in figure 8. The stem telescopes the collar on the burner box and conducts the heat up into the radiator, where it circulates upward and over the diaphragm, and out of the vent pipe. The chick guard fits in the hole made in the floor of the house, prevents the chicks from coming in contact with the stem, and serves as a passage for bringing the warmed, fresh air into the hover. All the parts of the heater are shown separately in figure 6.

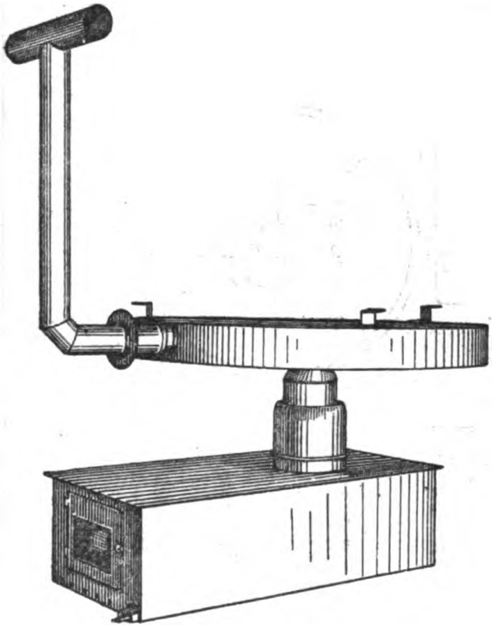

FIG. 7.—Gasoline heater used in brooder house.

Since there is only 1 flame to 200 chicks, instead of 4 as in case of using kerosene-heated brooders with only 50 chicks each, the risk of fire is reduced to that extent, and the authors maintain that anyone intelligent enough to be trusted with kerosene-heated brooders can manage gasoline-heated ones with equal safety.

A study of the following directions for operating this form of brooder will give an idea of how it compares with kerosene-heated brooders in cost, labor, efficiency, and safety:

> To operate this house in January and February weather requires about half a gallon of gasoline per day costing at the present rate of 15 cents per gallon, less than 7 cents per day. During the warmer weather, April and May, the cost is much less, as low sometimes as 2 cents per day to brood the 200 chickens. * * *
>
> The brooder is run for the first week or ten days so that the thermometer, located as mentioned above, gives a reading of 90° F., at the same time the thermometers placed under other parts of the hover would show a range of temperature from 90° to 103° F., thus making it possible for the chicks to get almost any degree of temperature from 60 out in the room, to 103 under the hover.
>
> Figure 8 shows how the tank is filled from the rear of the house. The burner should always be turned out and the wheel valve closed while the tank is being filled. To

light the burner, open the wheel valve (W W, fig. 8), and the control valve, and allow the gasoline to fill the generating cup [nearly full], then close. Light the gasoline and allow it to burn out. Open the control valve and hold a lighted match over the top of the burner. This will give a bright blue, cone-shaped flame, which should never be turned so high as to show red. Regulate to the desired temperature with the control valve.

There is no danger whatsoever in operating a gasoline burner provided ordinary care is exercised. The common points of error often resulting disastrously are: (a) Allowing too much gasoline to run into the generating cup; (b) applying a match to the generating cup before the control valve is closed; (c) attempting to light the burner after it has been blown out by the wind or in some other manner and the bottom of the burner box is covered with gasoline. With this type of heater this occurrence is very rare, since the burner is placed back under the house where the wind can not reach it. Should the flame by any accident be extinguished and the burner become cool and so waste gasoline into the burner box, the control valve should be closed as soon as it is discovered and the gasoline allowed to evaporate entirely before any attempt is made to relight the burner. As an extra precaution a basin may be placed outside under the drip to prevent waste and also to avoid gasoline filtering into the soil. A tin flashing should be placed about and below the burner box on the back side of the house as an extra precaution against fire.

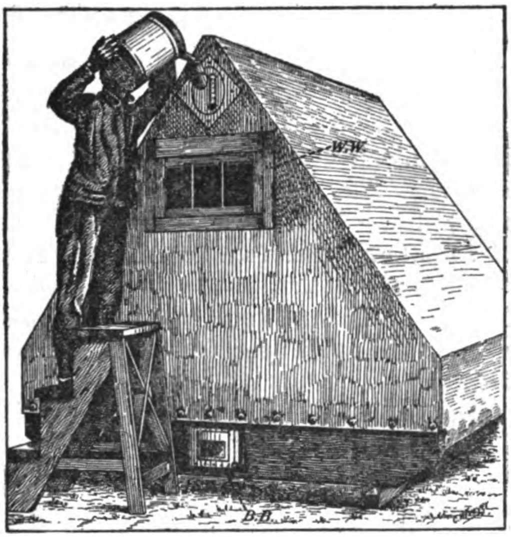

FIG. 8.—Method of filling gasoline heater in place.

Should any difficulty be experienced in getting a large enough flame to maintain the proper temperature under the hover during cold weather, the burner should be examined for stoppage. It sometimes happens that little particles of sediment in the gasoline clog the opening at the needle end of the control valve. This can be remedied by closing the control valve and forcing the point of the needle through the opening in the valve seat. This will clear away any obstruction that might be there. It might be difficult to get a sufficiently large blaze because the opening above referred to is too small. This may be remedied by opening the control valve so that the point of the needle will be back out of the way and then drawing a file at right angles across the hole, thus enlarging it. * * *

See that the house stands level. If it tips forward, the gasoline which would flow if the flame should be extinguished would remain in the burner box instead of escaping outside by the trough provided for the purpose. (Fig. 6.) * * *

While there is less danger from fire with gasoline when used as here recommended, nevertheless it is well to be prepared for fire by having a fire extinguisher or water supply at hand in case of need. It will be a wise precaution and profitable investment, whatever system of brooding is employed. * * *

Do not leave the hover raised without first extinguishing the flame. The wind is likely to blow down the stem of the heater and put out the flame, which would allow the gasoline to escape.

Never ignite the burner while there is gasoline or gasoline vapor free inside the burner box. If gasoline has escaped, wipe out the burner box thoroughly and allow a little time to elapse before igniting in order to let the vapor escape from the heater drum, thus avoiding an explosion of the gas.

The authors give a table showing the temperature maintained by one of these gasoline heaters for a period of 29½ days in the month of March. The average outside temperature was 40°, the average temperature of the brooder outside of the hover was 48°, and under the hover 89°. The cost of brooding one chick for sixty days, the time estimated that it needs heat, is 1.8 cents.

The estimated time saved during a brooding season is fifteen hours, which at 15 cents an hour is equal to $2.25.

MEASURING ACIDITY IN CHEESE MAKING AND BUTTER MAKING.[a]

A simple, accurate means of measuring acidity is of great importance to butter and cheese makers, because, as C. A. Publow, of the New York Cornell Station, points out, "one of the most important factors in the manufacture of cheese and butter is the control of acidity at all times." A number of methods have been devised and used for this purpose. In a recent circular of the New York Cornell Station Mr. Publow describes a new method in which, he believes, "most of the defects in other tests have been eliminated," and which contains features which make it "the most simple, durable, and accurate apparatus yet devised for the use of cheese makers in testing for acidity."

The apparatus and its method of use is described as follows:

THE ACIDIMETER.

The apparatus (see fig. 9) consists of—

1. A plain 5-pint bottle with an opening in the bottom, through which a brass pipe is connected in such a manner as to prevent leakage.
2. A small 2-ounce wash bottle, fastened to the neck of the large bottle by a copper band, and connected with rubber corks and glass tubing.
3. A plain 10 cubic centimeter burette, graduated in tenths, and a simple wire burette holder.
4. A straight, nonbulbous, 9-gram pipette, which is easily cleaned.
5. A simple rubber-stoppered dropper bottle.
6. A plain white cup and a stirring rod.
7. A small bottle containing 50 cubic centimeters of a solution of caustic soda, which, when added to 2,250 cubic centimeters of water, makes 2,300 cubic centimeters of a one-tenth normal alkaline solution. The large bottle is marked to show the level of 2,300 cubic centimeters in order to save measuring with a graduate each time.
8. A small bottle of phenolphthalein, to be used as an indicator.

Very few of the cheese makers and butter makers are able to make and standardize their own solutions to be used in such tests. For this reason a concentrated solution is advised, 50 cubic centimeters of which is sufficient to make 2,300 cubic centimeters of a one-tenth normal alkaline solution. This small amount is not costly and can be sent through the mails for a few cents. When tightly corked this solution will retain its strength indefinitely, so that it can be kept in stock in almost any place.

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[a] Compiled from New York Cornell Sta. Circ. 7.

The indicator is made by dissolving 5 grams of dry phenolphthalein in 100 cubic centimeters of 50 per cent alcohol. The commercial alcohol, which is about 95 per cent pure, can be used by diluting 50 cubic centimeters of it with 50 cubic centimeters of water. It can be purchased ready for use from dairy supply houses.

The preparation and successful handling of a good commercial starter for use in cheese making or butter making depends very largely upon the amount of acid allowed to develop in the starter from day to day. Uniformity is one of the great factors of success in dairy work, especially in the manufacturing department, and one need only know this to appreciate the value of any simple test that will enable him to measure the acid in his product as closely as one one-hundredth of 1 per cent.

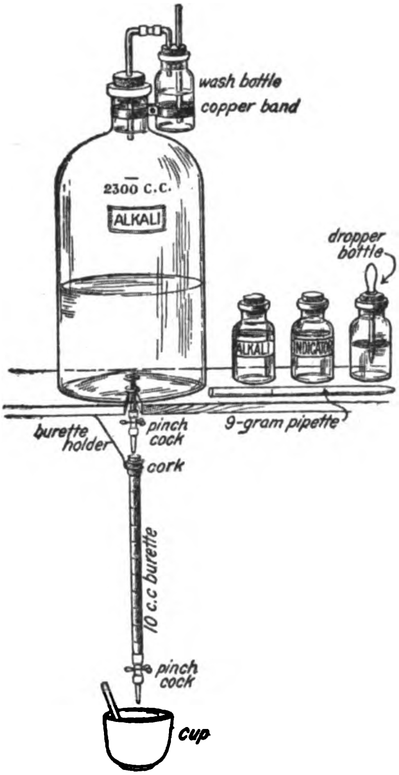

FIG. 9.—Apparatus for determining acidity in milk and cream.

By the use of such a test one is guided in controlling temperature and bacterial life associated with the manufacturing process, so that if the raw material reaches the cheese maker or butter maker in good condition there is no reason why he should not be able to turn out butter or cheese of uniform quality each day.

DIRECTIONS FOR USING THE ACIDIMETER.

How to set up the test.—In a convenient place erect a small shelf to support the large bottle. Cut a notch in the front or back of the shelf to allow the brass pipe to pass through.

Then add the contents of the small bottle of alkali to the large bottle, rinsing the small bottle several times, and each time pouring the rinsings into the large bottle. Then add soft water to the large bottle until the level reaches the mark filed on the bottle. You will then have 2,300 cubic centimeters of a one-tenth normal alkaline solution.

The small wash bottle attached to the neck of the larger one should be half filled with this solution. Then the rubber and glass connections are made between the two bottles.

The burette holder is fastened underneath the shelf so that the alkali from the large bottle can enter it. The dropper bottle is then filled with indicator.

To use the test.—Measure with a pipette 9 grams of the substance (milk, whey, cream, or starter) which you wish to test, and place it in the white cup. Add two drops of the phenolphthalein indicator. Then allow the alkaline solution to run into the cup from the burette, one drop at a time, until the fluid in the cup, which is being constantly stirred, shows a very faint pink color. By reading the graduations on the burette we can ascertain the amount of acid in the substance tested. Each one-tenth cubic centimeter of alkali represents one one-hundredth per cent of acid in the fluid.

AMOUNT OF ACID TO BE DEVELOPED AT EACH STAGE.

In cheese making.—The amount of lactic acid developed depends largely on the condition of the curd, and no fixed amount can be accepted as a set rule. Other conditions equal, the acidity should be uniform from day to day.

The proper firming of the curd in the whey before too much acid has been formed is the secret of cheddar cheese making, and with this fact in mind, the following directions should give accurate results:

(Export cheese.) Per cent.		(Home-made cheese.) Per cent.
0.20 to 0.21	before adding rennet	0.18 to 0.20
.14 to .145	before heating curd	.13 to .14
.16 to .18	before removing whey	.15 to .17
.24 to .30	when all whey is removed and curd is packed	.23 to .26
.65 to .75	before milling	.60 to .65
.90 to .110	before salting	.65 to .90
.70 to .80	in starter	.70 to .80

In butter making.—The amount of acid should vary with the amount of butter fat in the cream.

Per cent fat.	Per cent acid.
20	0.72
30	.63
40	.54
50	.45
In commercial starter	0.70 to .80

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 382.

THE ADULTERATION OF FORAGE-PLANT SEEDS.

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BY

F. H. HILLMAN,

Assistant Botanist, Seed Laboratory, Bureau of Plant Industry.

WASHINGTON:
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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 12, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "The Adulteration of Forage-Plant Seeds," prepared by Mr. F. H. Hillman, Assistant Botanist, and submitted by the Botanist in charge of the Seed Laboratory of this Bureau.

The adulteration of forage-plant seeds is a matter of great popular interest at the present time and the subject is treated in a practical manner in this bulletin.

Respectfully,
A. F. Woods,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE ADULTERATION OF FORAGE-PLANT SEEDS.

NATURE AND FORMS OF ADULTERATION OF SEED.

Farm seed is considered to be adulterated when it contains seed of inferior kind or quality in excessive quantity. When inferior seed is present in considerable quantity it is naturally presumable that intentional adulteration has been practiced.

The misbranding of seed, or its sale under the name of a different kind, may be intentional or it may be the result of error in labeling. Its effect, however, so far as the purchaser is concerned, is the same as adulteration.

Some of the plants whose seeds are used as adulterants have more or less forage value and are widely distributed in agricultural regions where farm seeds are produced. For this reason a comparatively small quantity of their seed is likely to appear in seed crops merely as an incident to the culture of these crops. When the small extent of such incidental occurrence is conspicuously exceeded, intentional adulteration is strongly suggested. An illustration of this is seen in the relation of yellow trefoil to red clover and alfalfa. The trefoil grows spontaneously in most regions where red clover seed and alfalfa seed are produced, and some trefoil plants are likely to appear in these crops. While trefoil is a low-growing plant, mostly escaping the mower when the crop is cut, some fruiting stems are likely to be harvested with the crop. The admixture of the trefoil seed with that of the crop is further aided by the fact that the trefoil has a long seeding period, and consequently its seed may appear in clover or alfalfa seed harvested at any time within the usual period during which harvesting may occur. Thus the appearance of a trace of trefoil in red clover or alfalfa seed does not indicate intentional or serious adulteration. Again, while Canada bluegrass grows spontaneously with Kentucky bluegrass it matures so much later than the latter that only very immature seed can appear incidentally in the harvested Kentucky bluegrass seed. The latter, however, as offered to the trade often contains mature Canada bluegrass seed in quantity varying from 10 per cent to complete substitution. This is evidently intentional adulteration.

As a rule, successful seed adulteration is made possible by the similarity existing between the inferior seed and that of the crop seed with which it is used. It often happens, therefore, that the adulterant used is the seed of some plant very closely related to the adulterated crop seed. The dealer who adulterates seed bases his faith in the success of the deception upon the very careless examination made or the absence of any examination of the seed by the average purchaser, including the majority of retail dealers. If, before purchasing, a careful examination of the seed offered for sale was made by all buyers, guided by a knowledge of the various adulterants used, seed adulteration would soon cease.

The combination of seeds of standard farm crops commanding uniformly different prices in the seed market constitutes adulteration when the mixture is sold at the price of the more expensive seed. This is illustrated by the combination of redtop and timothy offered as redtop.

Another form of adulteration is the use of dead seed of the kind offered for sale. Such dead seed may have lost its vitality from advanced age or from unfavorable conditions of harvesting or of storage, or it may consist of light screenings in which the seed germs never developed. (See fig. 15.) Old seed having very low vitality or none at all doubtless is often offered for sale. Considerable worthless shriveled red clover and alfalfa screenings are imported each year for use in adulterating red clover and alfalfa seed.

One of the commonest and most objectionable forms of adulteration is the use of low-grade screenings, consisting chiefly of miscellaneous weed seeds. (See fig. 5.) In many instances such adulterants have been purchased in foreign countries. The statement, often made, that low-grade weedy screenings are imported for the purpose of recleaning before being marketed is without foundation, because the quantity of good seed to be secured would cost the dealer more, usually very much more, than the same quantity of good seed produced in this country. Such low-grade seed, therefore, is unquestionably imported exclusively for use either in competition with or as an adulterant of higher grade seed.

ILL EFFECTS OF ADULTERATION.

Not all the consequences experienced by the consumer which arise from seed adulteration can be anticipated, but chief among the disadvantages are a reduced stand of the desired crop, a monetary loss in paying too much for the quantity of good seed actually secured, a loss in connection with transportation charges, which are higher than they should be for the actual quantity of good seed transported, and the securing of an undesired crop which, if from miscellaneous screenings, may do permanent injury to the farm owing to the noxious weeds introduced. Many indirect losses and disappointments resulting from the use of adulterated seed are experienced by progressive farmers who may unwittingly sow such seed.

KINDS OF FORAGE-PLANT SEEDS COMMONLY ADULTERATED AND THE ADULTERANTS USED.

The kinds of forage-plant seeds most subject to adulteration are red clover, alfalfa, alsike clover, orchard grass, meadow fescue, Kentucky bluegrass, redtop, and awnless brome-grass.[a] The character and extent of the adulteration vary with the kind of seed and the conditions of culture of the crop producing it.

RED CLOVER SEED.

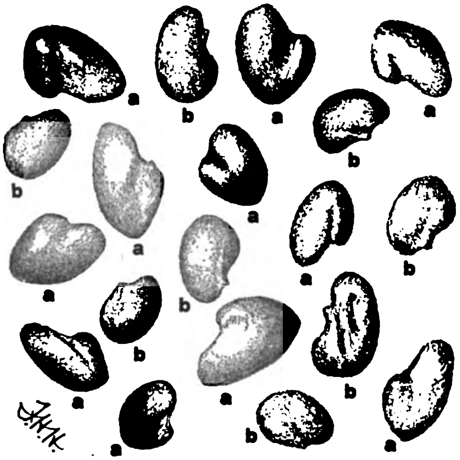

FIG. 1.—Mixture of seeds of red clover (*a*) and yellow trefoil (*b*). The clover seeds are more or less triangular, those of trefoil oval and usually with a distinct projection beside the scar notch. (Enlarged.)

Red clover seed is adulterated with imported yellow trefoil, which resembles the clover seed very closely and may easily escape detection. (See fig. 1.) A small quantity of trefoil may appear incidentally in the clover seed. In cases of adulteration, 30 to 40 per cent, or even 50 per cent, of the bulk may consist of trefoil.

The mixing of trefoil seed with better seed has practically all been done in this country. The development of public interest in the matter of seed impurities made within recent years, together with the publication of the names of dealers found to be handling adulterated seed, has resulted in a marked reduction in the importations of trefoil seed. A corresponding decrease in the quantity of red clover seed adulterated with trefoil has been observed. Tests of red clover seed made at the Seed Laboratory of this Department show that trefoil is used as an adulterant in variable quantities, sometimes exceeding 50 per cent. In the majority of cases it has amounted to over 20 per cent. The close similarity between trefoil seed and red clover seed renders detection of the trefoil by the average purchaser improbable unless sought especially with the aid of a magnifier.

The substitution of clover seed from the warmer parts of Europe for American-grown seed, which may be higher priced, amounts to adulteration, since it has been shown by various experiments that such seed is inferior to northern-grown American seed for crop production in the Northern States. This form of adulteration is indicated by the presence of an unusual quantity of very small clover seeds and by the kinds of weed seeds present.

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[a] Awnless brome-grass is also known as *Bromus inermis*, Hungarian brome-grass, smooth brome-grass, and brome-grass.

The presence of a large proportion of very small clover seeds from any source is equivalent to adulteration, since the crop-producing power of small seed is known to be inferior to that of large, well-filled seed.

The use of old seed having low vitality is a common form of adulteration and is influenced very largely by the extent of the surplus stocks of seed held from year to year by retail dealers. This form of adulteration should be easily detected through the contrast between old seed and new seed of clover.

No class of seed is so subject to adulteration with low-grade, weedy screenings as that of red clover. Some of these screenings may be of home production, but they often are imported as second and third grades of seed. The use of screenings doubtless has been the most prolific means of weed dissemination in this country.

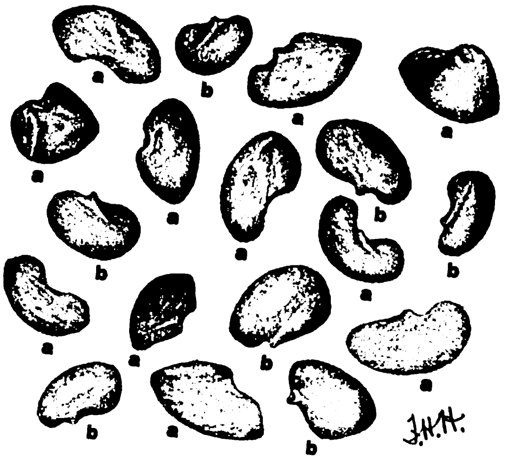

FIG. 2.—Mixture of seeds of alfalfa (*a*) and yellow trefoil (*b*). Alfalfa seeds are more or less kidney shaped or angular, while those of trefoil are more uniformly oval and have the small projection at the scar more commonly evident. (Enlarged.)

ALFALFA SEED.

Alfalfa seed is adulterated with trefoil essentially the same as in the case of red clover seed. The presence of the trefoil seed is even more obscured by the color of the alfalfa than by the color of red clover seed, and its detection is correspondingly less probable. (See fig. 2.) Tests of alfalfa seed made at the Seed Laboratory show that excessive quantities of trefoil, mostly over 35 per cent and sometimes over 50 per cent, are employed in adulterated lots. A decline in the quantity of alfalfa seed now adulterated with trefoil is observable, as in the case of red clover seed.

The seed of two kinds of bur clover has been employed to some extent in adulterating alfalfa seed. (See fig. 3.) The mixing appears to have been done in Europe, where the bur clover seed is a by-product of carding machines operating on Chilean wool. Alfalfa seed thus adulterated has been imported and widely distributed among retail dealers in this country. The quantity of bur clover seed employed is usually less than that used in the case of trefoil. In most instances observed it has been less than 6 per cent, but in some it has been over 10 per cent, reaching nearly 17 per cent in one instance and nearly 21 per cent in another. It is a noticeable fact that alfalfa seed adulterated with bur clover is usually adulterated also with trefoil.

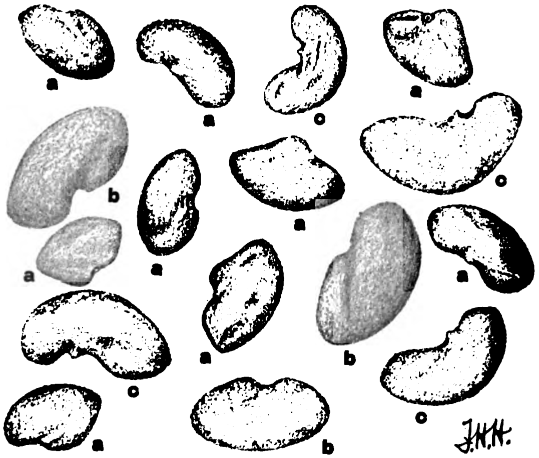

FIG. 3.—Mixture of seeds of alfalfa (*a*), toothed bur clover (*b*), and spotted bur clover (*c*). Note the larger size of the bur clover seeds, also the kidney shape of the spotted bur clover seeds, which have the scar near the smaller end. (Enlarged.)

The seed of sweet or Bokhara clover is sometimes to be considered in connection with the adulteration of alfalfa seed. Sweet clover is common along the irrigation ditches of the western alfalfa fields and small quantities of its seed frequently occur incidentally in American-grown alfalfa seed. Tests at the Seed Laboratory show that a trace of sweet clover is commonly found in alfalfa seed grown in the Western States. It is sometimes present to the extent of 3 per cent or even 5 per cent. Either of these percentages may be the result of intentional adulteration. (See fig. 4.)

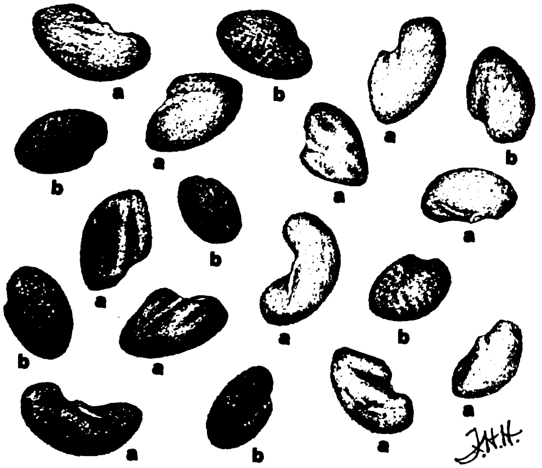

FIG. 4.—Mixture of seeds of alfalfa (*a*) and sweet clover (*b*). The elliptical form of the sweet clover seeds, which have the scar notch near one end, together with their uneven surfaces, serves to distinguish them from the more kidney-shaped alfalfa seeds. (Enlarged.)

The use of old alfalfa seed is practiced to some extent in adulterating new alfalfa seed, but its presence should be readily observed owing to the contrast between the colors of old and new seed.

The light, shriveled alfalfa screenings imported for the purpose of adulteration are totally worthless, since the seed germs are imperfectly developed. The shriveled appearance and dull, dark-brown color of this seed clearly distinguish it from fresh, well-filled seed. (See fig. 15.) When used it forms but a part of a sample of the adulterated seed, and for this reason may pass unnoticed in casual observation.

Much of the cheaper imported alfalfa seed which may be used in adulteration carries many kinds of pernicious weed seeds which should not be introduced to localities where alfalfa is still an experimental crop.

ALSIKE CLOVER SEED.

The adulteration of alsike clover seed is confined chiefly to the use of low-grade, weedy screenings. (See fig. 5.) The use of such material is favored by the dark color and small size of the alsike seeds. For this reason many kinds of small weed seeds are obscured and therefore overlooked by the indifferent purchaser. Various evidences of the importation of such screenings have been observed at the Seed Laboratory.

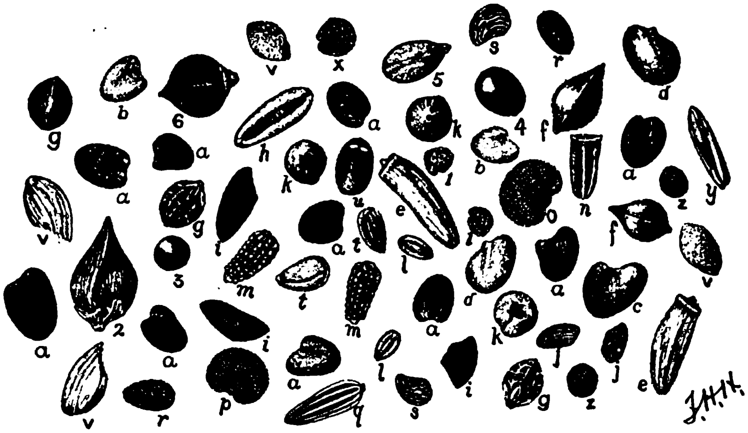

FIG. 5.—Mixture of weed seeds commonly found in low-grade alsike clover seed: *a*, alsike clover; *b*, white clover; *c*, red clover; *d*, yellow trefoil; *e*, Canada thistle; *f*, dock; *g*, sorrel; *h*, buckhorn; *i*, rat-tail plantain; *k*, lamb's-quarters; *l*, shepherd's-purse; *m*, mayweed; *n*, scentless camomile; *o*, white campion; *p*, night-flowering catch-fly; *q*, oxeye daisy; *r*, small-fruited false flax; *s*, cinquefoil; *t*, two kinds of peppergrass; *u*, catnip; *v*, timothy; *x*, chickweed; *y*, Canada bluegrass; *z*, clover dodder; *1*, mouse-ear chickweed; *2*, knot-grass; *3*, tumbling amaranth; *4*, rough amaranth; *5*, heal-all; *6*, lady's-thumb. (Enlarged.)

Canadian-grown alsike seed often contains considerable trefoil seed, since the trefoil plants are common in the fields of alsike. The lighter color and larger size of the trefoil seeds render them easily observed when mixed with alsike. (Compare figs. 13 and 16.) If trefoil is present in considerable quantity in alsike seed, either adulteration or incomplete cleaning is indicated.

Since alsike clover and timothy ripen at about the same time, mixed stands yield a mixed seed crop. Most of the timothy can be separated from the alsike, but mixed lots often pass in the trade as alsike seed. While a timothy and alsike mixture may not be objectionable as a crop in some instances, the timothy amounts to an adulterant when the mixture of seed is sold at alsike seed prices, which are three or four times higher than those of timothy.

ORCHARD GRASS SEED.

The adulteration of orchard grass seed is accomplished chiefly by the use of meadow fescue or English rye-grass seed, or both. (See fig. 6.) Each of those kinds of seed is cheaper than pure orchard grass seed. Meadow fescue seed sells at one-half to two-thirds the price of orchard grass, while rye-grass varies in price from one-third to one-half that of orchard grass. The close similarity of the seeds of these three grasses makes this a popular form of adulteration. Distinguishing differences between the kinds are readily disclosed, however, by careful examination under a lens. Tests of 265 samples of orchard grass seed made at the Seed Laboratory in 1905 showed 133 samples, or slightly over one-half of those tested, to contain one or both of these adulterants. Of the adulterated samples 59 contained 25 per cent or over of the adulterant and 7 were adulterated to the extent of one-half or over. The fact that 24

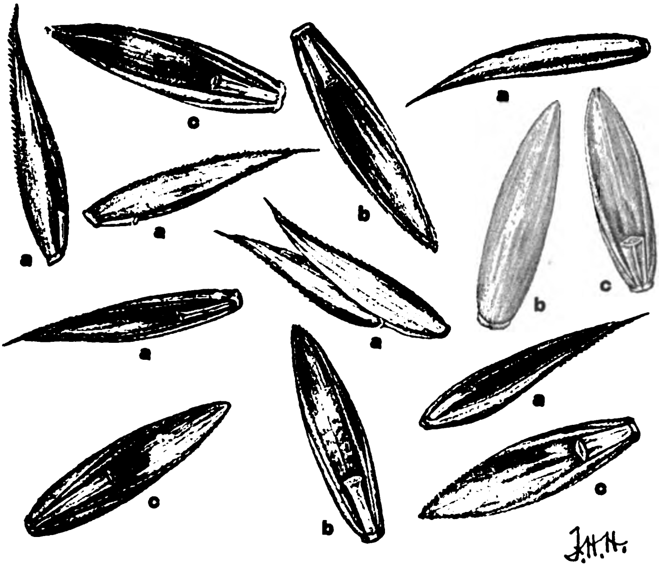

FIG. 6.—Mixture of seeds of orchard grass (*a*), meadow fescue grass (*b*), and English rye-grass (*c*). The orchard grass seeds are distinguished from the others by their slender, curved form. The meadow fescue and rye-grass seeds are distinguished by the difference in the section of the seed-cluster axis (rachilla segment) which each bears. (Enlarged.)

States were represented by the samples tested showed the wide extent of this adulteration in the retail trade at the time mentioned.

It is gratifying to note that tests covering 343 samples sold as orchard grass in 1908 showed but 53 samples, or 15.45 per cent, to be adulterated. In these cases meadow fescue and English rye-grass seed were chiefly employed. In two instances chess seed was used, amounting to nearly 18 per cent in one case and nearly 23 per cent in the other. In one instance over 21 per cent of the sample consisted of Canada bluegrass seed.

Chaff screenings containing little matured orchard grass seed but having the appearance of good seed make up a considerable part of some lots of seed. Such seed is essentially adulterated, and, furthermore, as a rule the screenings carry various weed seeds.

MEADOW FESCUE SEED.

Chess, or cheat, is one of the commonest impurities of meadow fescue seed, varying in quantity from a trace to 5 per cent or over. (See fig. 11, *b*, *d*.) One sample examined at the Seed Laboratory contained over 16 per cent of chess; three others contained over 19 per cent. In each of these four instances adulteration was suggested not only by the large quantities of chess but also by the presence of English rye-grass seed, which is sometimes used as an adulterant of meadow fescue seed. (See fig. 11, *b*, *c*.) In one of these cases over 62 per cent of the lot consisted of English rye-grass seed. The mistaking and substitution of chess for meadow fescue seed is mentioned in Press Bulletin No. 25 from the Nebraska experiment station; also in Kansas station Bulletin No. 141.

While meadow fescue seed is cheaper than that of orchard grass and is used as an adulterant of the latter, it often contains orchard grass seed, sometimes in considerable quantity. Old, worthless orchard grass seed or screenings being cheaper than the fescue seed may be used in adulterating the latter.

KENTUCKY BLUEGRASS SEED.

The chief adulterant of Kentucky bluegrass seed is the seed of Canada bluegrass, so called because it is produced chiefly in Canada. This is an inferior kind of true bluegrass not adapted to the purposes or crop requirements of Kentucky bluegrass. It grows spontaneously, however, throughout the eastern United States. It often appears in crops of Kentucky bluegrass harvested for seed. Since the Canada bluegrass matures its seed several weeks later than the Kentucky bluegrass its mature seed does not appear in the Kentucky bluegrass seed crop as it is ordinarily harvested. Immature Canada bluegrass chaff sometimes appears, however, in chaffy samples of

Kentucky bluegrass seed. Most, if not all, of the Canada bluegrass seed used in the trade is imported from Canada. As there is very little legitimate demand for it these importations are mostly for use in adulteration. The close resemblance existing between the seeds of these two bluegrasses permits the complete substitution of the inferior kind for the other with little danger of detection by purchasers. (See fig. 7.) The seed of Canada bluegrass costs from one-third to one-half as much as Kentucky bluegrass seed.

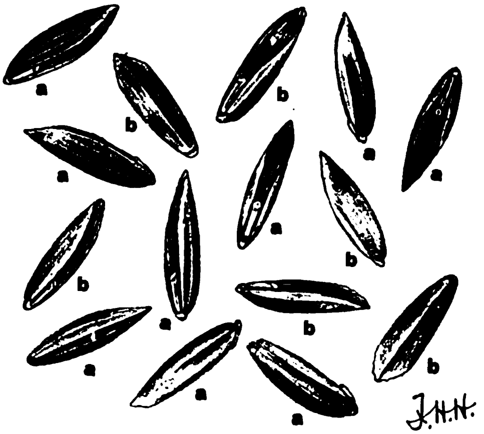

FIG. 7.—Mixture of seeds of Kentucky bluegrass (*a*) and Canada bluegrass (*b*). The Kentucky bluegrass seeds are broadest at the center, pointed, and have a distinct ridge on each side. Canada bluegrass seeds are mostly broadest near one end, blunt, and smooth on the sides. (Enlarged.)

Tests made at the Seed Laboratory and at various experiment stations show that much adulterated Kentucky bluegrass and Canada bluegrass seed substituted for Kentucky bluegrass seed is on the market. Of 251 samples of seed sold as Kentucky bluegrass which were examined at the Seed Laboratory in 1905, 41 samples, or over 16 per cent, were found to be adulterated with Canada bluegrass seed. Tests of 357 samples of seed sold as Kentucky bluegrass seed in 1908 showed 39 samples, or nearly 11 per cent, to be adulterated or misbranded. In 14 of these samples other seed had been substituted for the proper seed, Canada bluegrass seed being used in 12 instances and meadow fescue, or English bluegrass, seed in the other 2.

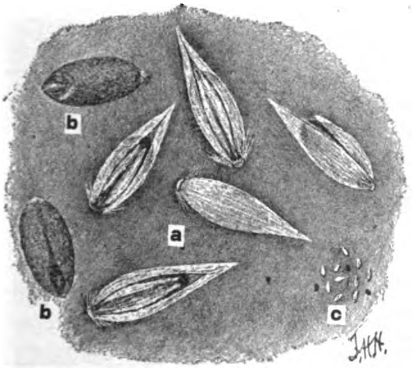

FIG. 8.—Seeds of redtop representing the "fancy" grade of the trade: *a*, different views of seeds having the white, papery, inner chaff; *b*, two views of a grain, or kernel, with the inner chaff removed; *c*, the same, natural size.

Poorly cleaned Kentucky bluegrass seed is likely to contain much light chaff devoid of seed. The deceiving nature of such chaff renders its use equivalent to adulteration.

The careless methods employed in curing Kentucky bluegrass seed followed by some producers results in killing much of the seed by overheating. Since such dead seed maintains the weight of good seed it can readily be mixed with the latter, when its detection, unless by its musty odor, can be accomplished only by making a germination test.

REDTOP SEED.

The seed of redtop appears on the market in two distinct grades under the trade names "fancy," "choice," or "recleaned" (fig. 8) and "chaffy" or "unhulled" (compare figs. 8 and 9). The chaffy grade is variable in quality, sometimes containing very little good seed. Its misleading character is sufficient to make it equivalent to an adulterant in some instances.

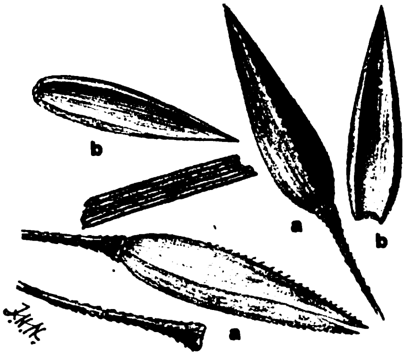

Fig. 9.—Chaff of redtop seed: *a*, whole spikelets usually devoid of seed in "chaffy" grades; *b*, separated scales of the same; *a* and *b* represent the outer chaff of the seed. (Enlarged.)

Timothy seed (fig. 10) is a common adulterant of redtop, particularly the fancy or recleaned grade. The price of timothy is commonly from one-half to four-fifths that of the fancy redtop. Tests have shown many instances of redtop containing from 5 to 10 per cent and over of timothy. A selection of samples marked "fancy" or "choice" and found to contain timothy showed this adulterant present in amounts varying from nearly 10 per cent to over 22 per cent. This grade of redtop should be practically free from timothy and chaff.

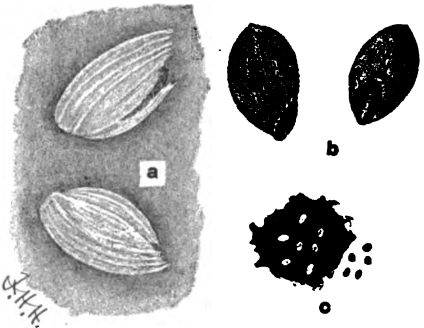

Fig. 10.—Seeds of timothy: *a*, grains in the hull, or chaff; *b*, grains removed from the chaff; *c*, the same, natural size.

AWNLESS BROME-GRASS SEED.

Awnless brome-grass seed is sometimes adulterated with either meadow fescue seed or with the seed of chess, or cheat. (See fig. 11). In some cases both kinds are present. Press Bulletin No. 25 from the Nebraska experiment station states that chess is sometimes substituted for brome-grass seed. Tests at the Seed Laboratory show that chess is frequently present in brome-grass seed in quantities varying from a trace to over 5 per cent. It has been found to amount to 17 per cent of the total bulk. While a relatively high percentage of the chess may occur incidentally, intentional adulteration is sometimes indicated.

Meadow fescue seed is a common impurity of brome-grass seed, often exceeding 5 per cent. In instances observed at the Seed Laboratory it amounted to 12 and 19 per cent, respectively. In another instance meadow fescue and English rye-grass seed together amounted to over 24 per cent of the lot. Meadow fescue may occur incidentally in the seeding crops of brome-grass, but the large quantities of seed mentioned amount to adulteration.

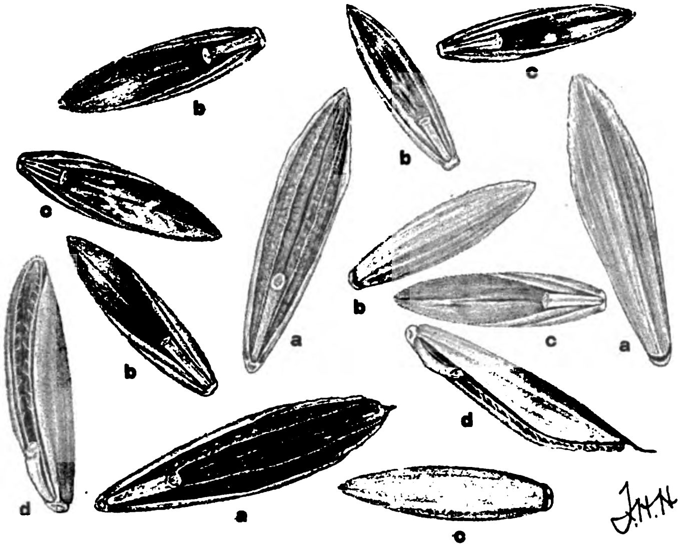

FIG. 11.—Mixture of seeds of awnless brome-grass (*a*), meadow fescue (*b*), English rye-grass (*c*), and chess, or cheat (*d*). The brome-grass seeds are distinguished by their greater length and flattened form. The seeds of chess (*d*) are somewhat cylindrical, due to being folded lengthwise. They are thus thicker than the awnless brome-grass seed and sometimes are awned. (Enlarged.)

FORAGE-PLANT SEEDS AND THEIR ADULTERANTS DESCRIBED.

GENERAL CHARACTERISTICS.

The seeds of the more common forage plants represent two general groups of plants—legumes and grasses. The same is true of most of the adulterants used.

Leguminous seeds of this class are mostly free from the pod or other covering. Their surface is usually smooth and the form is largely dependent on the shape of the contained germ or embryo, which consists chiefly of a stemlet bearing a root tip and a pair of fleshy seed leaves, or cotyledons. The embryo is folded upon itself, the stemlet being bent over against the edges of the two cotyledons.

A notch on the edge of the seed and between the ends of the folded embryo contains the seed scar. (See fig. 12.)

Seeds of grasses are more complex and variable in structure. They usually consist of two or more scales constituting most of the "chaff" surrounding the kernel, or grain, which contains the germ. (Compare figs. 6 to 11, inclusive.) The chaff scales immediately surrounding the grain have the characters which indicate the kind to which the seed belongs. In some grasses the kernel, or grain, separates more or less readily from the chaff, as in redtop and timothy. (See figs. 8 and 10.) In such grass seeds as those of orchard, fescue, and rye grasses the chaff persists and marks the different kinds by its form and structure.

Most of the grass seeds subject to adulteration have the kernel, or grain, surrounded by only two scales, one larger than the other and called the lemma. The lemma has more or less distinct nerves or veins along its back or convex face. It may have a bristle, or awn, projecting from the apex in certain kinds. Some oat seeds have such an awn projecting from near the middle of the back. The lemma incloses a smaller, thin, two-veined scale called the palea, or palet. The grain lies between the lemma and the palet. At the base of the palet in such grasses as orchard grass, fescue grass, rye-grass, and the bluegrasses is a short appendage, the rachilla segment. It is a section or "joint" of the axis of the flower and seed cluster of the grass. The form of the segment differs somewhat in the seeds of different grasses. In redtop and timothy the rachilla segment is absent. The color of most of the grass seeds of this class varies from light-straw color to light brown.

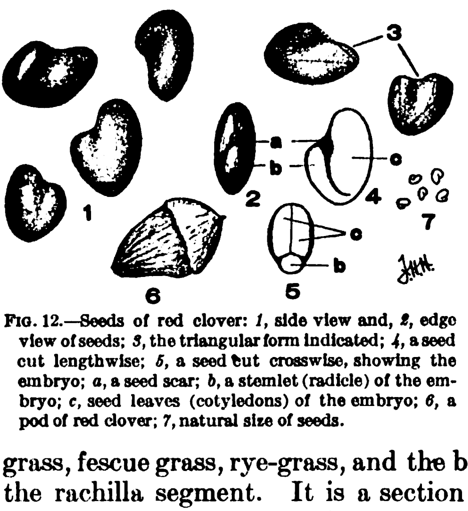

FIG. 12.—Seeds of red clover: *1*, side view and, *2*, edge view of seeds; *3*, the triangular form indicated; *4*, a seed cut lengthwise; *5*, a seed cut crosswise, showing the embryo; *a*, a seed scar; *b*, a stemlet (radicle) of the embryo; *c*, seed leaves (cotyledons) of the embryo; *6*, a pod of red clover; *7*, natural size of seeds.

These general characteristics of leguminous and grass seeds are those to be observed when examining such seeds under a magnifier for adulterants.

The principal characteristics by which this class of seeds and their adulterants may be distinguished are stated in the following descriptions.

Red Clover Seed.

The seed of red clover may be distinguished from other leguminous seeds by its color. Some seeds are violet, others light yellow, and others variegated in having both colors. Individual seeds are flattened and somewhat triangular, with rounded angles. (See fig. 12.)

New seed is clear and bright and has a slight luster; old seed becomes dull and reddish brown.

Effort is sometimes made to give old, dead seed an appearance of newness by oiling and rubbing the seed. Such treated seed has an unnaturally high luster, but the fresh violet and yellow colors are not recovered. An unusually high luster, therefore, indicates adulteration.

The size of individual seeds in any sample of red clover seed shows considerable variation. When all the seed or a considerable part of it consists of very small seeds it may be considered as inferior. The largest seed now found on the market is that imported from Chile. The smallest is the low-grade seed brought from Europe.

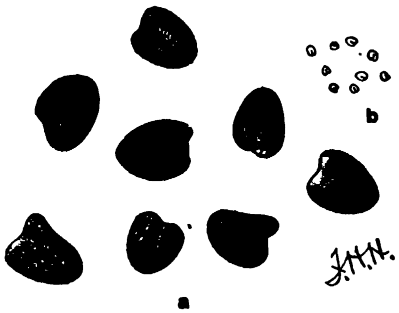

FIG. 13.—Alsike clover seeds: *a*, seeds showing variation in form and surface appearance, enlarged; *b*, natural size of seeds.

Alsike Clover Seed.

The conspicuous green color of alsike seed distinguishes it from the seed of other clovers. Some seeds are very dark green, while others are light olive-green and somewhat mottled. Old seed becomes brown. The seeds are smaller than those of red clover and somewhat oval heart shaped in outline. The form is practically the same as that of white clover seed, which is yellow or reddish yellow. (See fig. 13.)

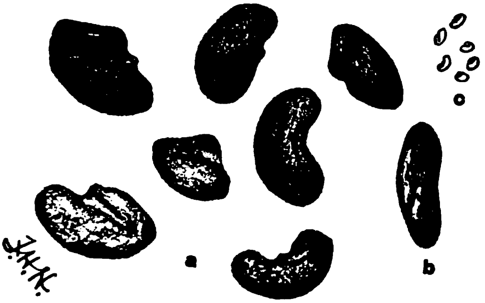

FIG. 14.—Alfalfa seeds: *a*, individual seeds, showing variation in form; *b*, edge view of a seed, showing the scar; *c*, natural size of seeds.

Alfalfa Seed.

Considerable variation in the form of alfalfa seeds is observable, due to the fact that several seeds are produced in each pod. The somewhat kidney-shaped form of these seeds readily distinguishes them from the true clover seeds. Some seeds are somewhat triangular. The greenish yellow color, together with the usually evident light stripe leading from the scar toward one end, distinguishes alfalfa seeds from other crop seeds. The seed scar is near the center of the seed. Some of the more kidney-shaped seeds have a projecting point beside the scar marking the position of the root tip of the embryo. (See fig. 14.) Well-developed alfalfa seed is well filled and plump.

Poorly developed seeds contain a thin, shriveled germ and so are thin and wrinkled. Such seeds are, however, often even longer and broader than plump seeds, but the thin and wrinkled appearance, together with the usually dull-brown color, readily indicates inferiority. (See fig. 15.)

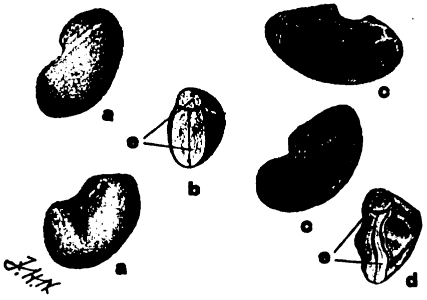

Fig. 15.—Plump and shriveled alfalfa seeds: *a*, well-filled, plump seeds; *b*, cross section of a well-filled seed, showing the thick embryo (*e*); *c*, shriveled seeds, thin and having a wrinkled seed coat; *d*, cross section of a shriveled seed, showing the thin, worthless embryo (*e*). (Enlarged.)

Yellow Trefoil Seed.

Yellow trefoil seed is about the same size as that of red clover and alfalfa. Its color is near that of alfalfa seed and the lighter yellow clover seeds. The seeds are oval, or egg shaped, in outline and slightly notched at the scar near the smaller end. A slight projecting point, or protuberance, beside the scar indicating the root tip of the embryo is nearly always evident. This, together with the oval form and the absence of violet, renders trefoil easily distinguishable from red clover seed. The form of the trefoil alone distinguishes it from alfalfa seed, barring occasional seeds of either kind which may be very similar to those of the other. No difficulty should be experienced in distinguishing trefoil seed when used as an adulterant of alfalfa seed. (See fig. 16.)

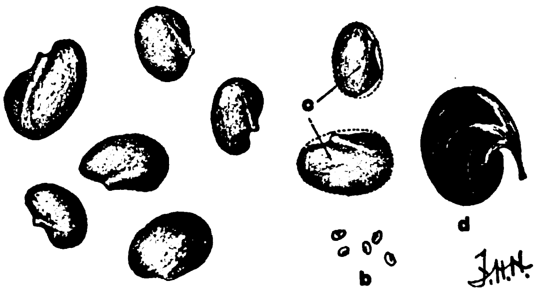

Fig. 16.—Seeds of yellow trefoil: *a*, seeds showing variation in form and size; *b*, natural size of seeds; *c*, oval form of trefoil seeds indicated; *d*, a pod of trefoil.

Bur Clover Seed.

The seed of bur clover is closely related to alfalfa seed and is also very similar to it. Two kinds, toothed and spotted bur clover, are involved. The seed of toothed bur clover is somewhat kidney shaped or oval, as shown at *b*, figure 3. These seeds are mostly longer than alfalfa seeds and have a dull, yellowish or light-brown surface. The notch at the scar is usually prominent and the root tip does not project as a pointed protuberance. Seeds of spotted bur clover, shown at *c*, figure 3, are more commonly kidney shaped, sometimes conspicuously so. Some of them are longer than alfalfa seeds, while many are about the same size or smaller. The protuberant root tip is usually clearly evident and noticeably nearer one end of the seed than in alfalfa seed. Some of these seeds are dull, others possessing a bright, fresh appearance. The seeds of this kind are mostly light yellow.

Sweet Clover Seed.

The seeds of sweet clover are very uniformly elliptical in general outline, the scar notch being near one end. The seeds are about the size of those of red clover and alfalfa. The color is yellowish brown and the rather dull surface is slightly uneven. The form and surface appearance must be depended upon in detecting free seeds of sweet clover mixed with alfalfa seed. If 5 to 10 per cent, or over, of a sample consists of sweet clover seed, its characteristic odor becomes evident. In nearly all cases of the presence of sweet clover in excess of a trace, a few of the unopened pods of this clover accompany the seed. The pods inclose a single seed and are rough, due to a coarse network of ridges. The color varies from light brown to dark brown. (See fig. 17.)

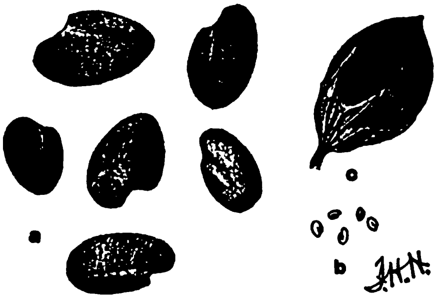

FIG. 17.—Seeds of sweet clover: *a*, seeds showing variation in form and size; *b*, natural size of seeds; *c*, a pod of sweet clover.

Orchard Grass Seed.

Orchard grass seed is to be distinguished by the characteristic form of the individual seeds, which differs from that of other seeds. These seeds are lance shaped, tapering to an awn-pointed apex, which is bent to one side. The back of the lemma is sharply angled, the angle being more or less hairy, especially toward the apex. (See fig. 6, *a*.)

Meadow Fescue, or English Bluegrass, Seed.

Meadow fescue seeds are larger than orchard grass seeds, straight, and broadly lance shaped or boat shaped. The apex is not awned. The back of the lemma is rounded instead of angled, as in orchard grass. The rachilla segment is cylindrical, nearly straight, and abruptly expanded at the apex. The form of the segment distinguishes this seed from that of English rye-grass. (See fig. 6, *b*, and fig. 11, *b*.)

English Rye-Grass Seed.

The seed of English rye-grass is very similar in general appearance to that of meadow fescue. The form and size of individual seeds are essentially the same as in the fescue seed. A distinguishing difference appears, however, in the form of the rachilla segment, which is flattened, wedge shaped, and expanded but very slightly, if at all, at the apex. (See fig. 6, *c*, and fig. 11, *c*.)

Italian Rye-Grass Seed.

The seed of Italian rye-grass may be distinguished, as a rule, from English rye-grass seed by the presence of a slender awn from the apex of the lemma. Some of the seeds of this grass are devoid of the awn. The rachilla segment in Italian rye-grass seed is generally a little narrower than that of English rye-grass.

Awnless Brome-Grass Seed.

The seeds of awnless brome-grass are larger than those of the other grasses discussed. They are broadly lance shaped and much flattened, being relatively thinner than other grass seeds. The papery apex is acute or sometimes has a short awn. The palet is exposed and exhibits two slender veins, and usually a slender groove along its center, in ripe seeds. The dark-colored grain is evident through the palet. These seeds are mostly light brown. (See fig. 11, *a*.)

Chess, or Cheat, Seed.

Chess seeds are robust and more or less folded cylindrically. The back is rounded and the inner face bearing the palet is deeply grooved. The apex usually bears a short awn which readily breaks away. The palet veins are coarsely hairy, while in awnless brome-grass seed they are very finely hairy. The rachilla segment is club shaped and curved. (See fig. 11, *d*.)

Kentucky Bluegrass Seed.

The seed of Kentucky bluegrass is marketed "in the chaff," but the methods of cleaning the seed used in localities of large production should remove all superfluous chaffy material, including undeveloped light seed, leaving the individual seeds in essentially the condition shown in figure 7. This seed in bulk has a light-brown color, which is darkest in the best-cleaned pure seed. Light-weight chaff lightens the general color of the seed in bulk. The identity of this seed can be determined with certainty only when examined under a lens. Three characteristics of structure serve to distinguish this seed with certainty. They are as follows: Form, distinctness of veins of the lemma, and the coarseness of the hairs on the veins of the palet. These seeds are somewhat canoe shaped, the back of the lemma being sharply keeled. The apex of the lemma of the seed is usually pointed if not broken away in the process of cleaning for market. The seed is therefore broadest at the middle, which is the characteristic form of this seed. (See fig. 7, *a*.) Each lateral half of the lemma bears a distinct vein forming a ridge parallel with the keel of the lemma. The appearance of these veins, called lateral or intermediate veins, is very characteristic of Kentucky bluegrass seed. The hairs on the veins of the palet are relatively few and coarse in this seed. They can be distinguished only by means of a good magnifier or a microscope. This character does not need to be considered in ordinary cases of adulteration, since the form of the seed and the distinctness of the intermediate veins are sufficient.

Canada Bluegrass Seed.

Canada bluegrass seed is generally lighter colored in bulk than Kentucky bluegrass seed. Since the Canada thistle is very common in southern Canada this grass seed usually contains numerous prickles of the thistle. Some seedsmen depend upon the color of the seed and the presence of the prickles to distinguish Canada bluegrass seed. This is unreliable, since the color varies and the similar prickles of horse nettle are common in pure Kentucky bluegrass seed. This seed is to be distinguished from that of Kentucky bluegrass by the broader form of individual seeds, indistinct veins, and numerous fine hairs on the palet veins. The apex of the lemma is often papery and rounded and somewhat flaring. The seed is therefore very often broader above than at the middle. (See fig. 7, *b*.) The lateral veins are very indistinct or apparently absent, giving the side of the seed a smooth, rounded appearance. The hairs on the palet veins are very numerous and fine. The form and indistinct veins as observed under a magnifier suffice to distinguish this seed in cases of adulteration. A few seeds having much the same form as Kentucky bluegrass seeds are to be found in all samples of Canada bluegrass seed, but sufficient seed similar to that shown in figure 7, *b*, is always present in samples and is readily distinguishable under the magnifier.

HOW TO TEST SEED FOR ADULTERANTS.

It is to be observed from the preceding statements relating to the various seed adulterants that in some instances the general appearance of the small bulk sample is evidently influenced by the presence of the adulterant, as in the use of trefoil in red clover, shriveled screenings in alfalfa seed, or weedy screenings in any of the farm seeds. The detection of specific kinds of adulterant seeds, however, usually requires the use of a magnifier or lens.

The most convenient magnifier for this purpose is, doubtless, the tripod magnifier shown in figure 18. It costs from 50 to 75 cents and is usually obtainable from opticians or manufacturers of optical goods.

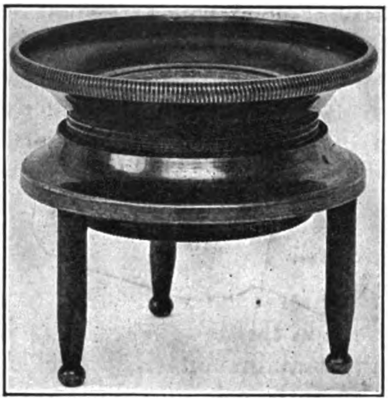
FIG. 18.—Magnifying glass.

Seed to be examined for adulterants should be spread thinly on white paper so that individual seeds may be examined critically. The foregoing descriptions and illustrations should suffice to enable one to recognize the common crop seeds and their adulterants.

The relative proportion, or the percentage, of adulteration can be practically determined by counting out 500 or 1,000 seeds of the mixed crop seed and of the adulterant freed from other impurities. The crop seed and the adulterant are then separated and their relative number determined by count.

Seed suspected of having lost its vitality, due to age or unfavorable conditions of harvesting, should be tested for its ability to germinate.

The percentage of seed that will grow can easily be determined by means of the simple tester shown in figure 19. Two dinner plates and a piece of canton flannel or some other similar cloth about twice the size of the plates are needed for this test. Blotting paper as well as cloth is suitable for this purpose.

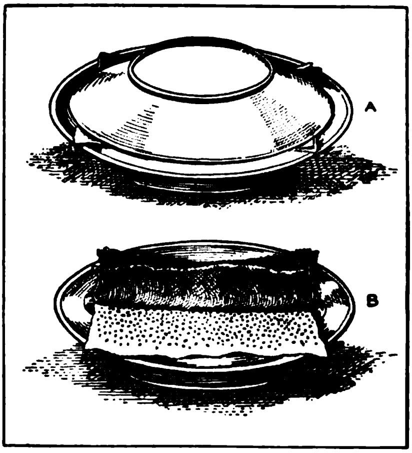

FIG. 19.—Homemade seed tester: A, closed; B, open.

The seeds which have been picked out should be thoroughly mixed and 100 or 200 seeds counted, just as they come, making no selection.

The cloth should be well moistened, one thickness being laid on one of the plates and the counted seeds placed on it, the other part of the cloth being spread over the seed, covered with the second plate, and kept at a temperature of about 70° F. On the second and each succeeding day the sprouted seeds should be taken out and counted.

The periods during which the crop seeds discussed in this paper germinate under favorable conditions are as follows: Clovers and alfalfa between the 3d and 6th days, timothy and redtop between the 5th and 8th days, meadow fescue and awnless brome-grass between the 5th and 10th days, orchard grass and rye-grasses between the 6th and 14th days, and Kentucky bluegrass between the 14th and 28th days. Many seeds which germinate slowly, including those of most of the grasses, require an alternating temperature and should be kept at about 70° F. for eighteen hours and 86° F. for six hours each day.

Samples of seed suspected of being adulterated can be sent to the Seed Laboratory, Department of Agriculture, Washington, D. C., for examination for adulterants. The presence or absence of adulterants will be reported upon at once. The determination of the quantity of the adulterant is likely to delay the report.

Residents of Missouri may send samples to the Seed Laboratory, Agricultural Experiment Station, Columbia, Mo.; those of Nebraska may address samples in the same way to the station at Lincoln, while those of Oregon may address the Seed Laboratory of the station at Corvallis. No charge is made for any of these tests.

SUMMARY.

(1) Serious and intentional adulteration of important forage-plant seeds is frequently practiced. Seed is sometimes misbranded.

(2) It is possible for purchasers to detect most kinds of adulteration or misbranding of farm seeds.

(3) In detecting adulteration it is necessary to know what kinds of seeds are subject to adulteration, the means employed in adulteration, and the distinguishing characters of both the crop and the adulterant seeds.

(4) A cheap magnifier suffices in distinguishing crop seeds from other kinds of seeds used as adulterants.

(5) A simple germinating test discloses the use of dead crop seed as an adulterant.

(6) The illustrations used in this bulletin were prepared especially to enable purchasers of farm seeds to distinguish seeds subject to adulteration and those used as adulterants.

(7) It is not the purpose of the bulletin to enable one to determine the extent of adulteration in each instance, but rather the more important fact of its existence.

(8) A little effort on the part of the purchasers of seeds directed to the detection of adulteration or misbranding will prevent many instances of crop failure.

(9) It is advisable to make tests for adulteration at home; otherwise the suspected seed may be sent to the Seed Laboratory at Washington or to the cooperative laboratories in Missouri, Nebraska, or Oregon. A report on the matter of adulteration will be made promptly and without charge.

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Issued January 20, 1910.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 383.

HOW TO DESTROY ENGLISH SPARROWS.

BY

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Assistant, Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., November 20, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a report by N. Dearborn, Assistant, Biological Survey, on How to Destroy English Sparrows. Introduced into the United States many years ago from Europe, this sparrow has multiplied and extended its range until now it is numerous and firmly established over most of the country. The bad qualities of the bird far outweigh its good ones, and, although its extermination is impracticable, a reduction of its numbers is feasible and important. The present bulletin aims to describe the best methods of destruction.

Respectfully,

H. W. Henshaw,
Acting Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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HOW TO DESTROY ENGLISH SPARROWS.

INTRODUCTION.

In its economic relations the English sparrow among birds is comparable to the rat among mammals. It is cunning, destructive, and filthy. This sparrow was introduced into America about sixty years ago, and is now distributed generally over the eastern half of the United States and southern Canada and locally westward to the Pacific coast. This rapid dissemination is a result of the bird's hardiness, extraordinary fecundity, diversity of food, aggressive disposition, and almost complete immunity from natural enemies through its sagacity and its preference for thickly settled communities.

Its natural diet consists of seeds, but it eats a great variety of other foods. While much of its annual fare consists of waste material from the streets, in autumn and winter it consumes quantities of weed seed, and in summer numerous insects. The destruction of weed seed is undeniably in the sparrow's favor. Its record as to insects is not so clear. There is substantial evidence that it eats certain harmful insects quite freely when these are abundant, but that it habitually seeks insects, or that it prefers them to seeds or other vegetable food, is not borne out by the evidence. Out of 522 English sparrow stomachs examined by the Biological Survey,[a] 47 contained noxious insects, 50 contained beneficial insects, and 31 contained insects of little or no economic importance. This report shows conclusively that, aside from the destruction of weed seed, there is very little to be said in the sparrow's favor.

On the other hand, much can be said against the bird. It destroys small fruits, as cherries, grapes, pears, and peaches. It also destroys buds and flowers of cultivated trees, shrubs, and vines. In the garden it eats seeds as they ripen, and nips off tender young vegetables as they appear above ground, peas and lettuce being especially subject to attack. It damages wheat and other grains when newly sowed, ripening, and in shocks. It reduces the numbers of some of

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[a] U. S. Department of Agriculture, Division of Economic Ornithology and Mammalogy, Bulletin 1, The English Sparrow in North America, p. 143, 1889. An exhaustive account now out of print.

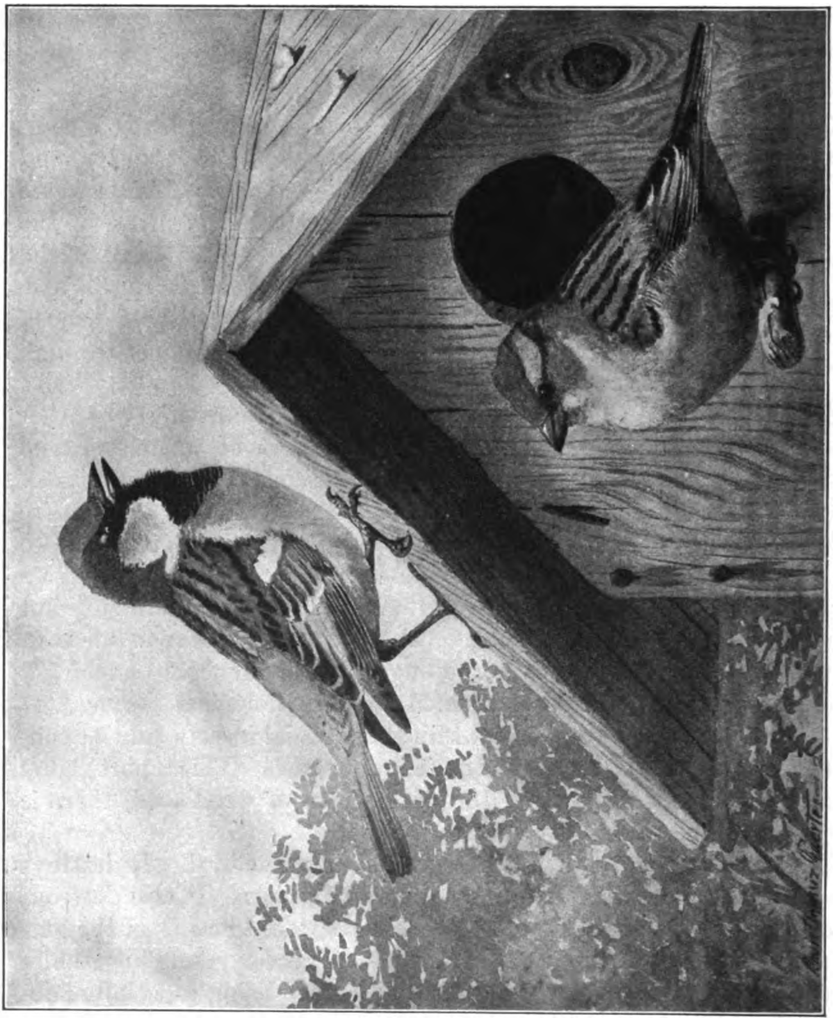

FIG. 1.—English sparrow, male and female, showing the manner in which they take possession of nesting boxes provided for native birds.

our most useful native species, such as bluebirds, house wrens, purple martins, tree swallows, cliff swallows, and barn swallows, by destroying the eggs and young and by usurping the nesting places. It attacks other familiar native birds, as the robin, wren, red-eyed vireo, catbird, and mocking bird, causing them to desert parks and shady streets of towns. Unlike our native birds whose places it usurps, it has no song, but is noisy and vituperative. It defiles buildings and ornamental trees, shrubs, and vines with its excrement and with its bulky nests.

The evidence against the English sparrow is overwhelming, and the present unfriendly attitude of the public toward it is reflected in our State laws. Nowhere is it included among the birds that are protected. In response to frequent inquiries for means of abating the sparrow nuisance received by the Biological Survey, a few approved methods applicable to different conditions are here described.

Sparrows frequently give annoyance by roosting in ornamental vines and in crevices about buildings. If driven out late at night, several nights in succession, they will usually desert the roost. A jet of water from a garden hose is a potent disturber, particularly on frosty nights. Where water is not available, small Roman candles may be employed.

Though sparrows may be driven from a given neighborhood, the relief thus obtained is only temporary, and has the further objection that the nuisance is simply transferred elsewhere. More drastic action is therefore preferable.

PREVENTION OF INCREASE.

The most effective method of preventing the increase of sparrows in a locality is to destroy their nests at intervals of ten or twelve days throughout the breeding season. Occasionally they build large covered nests in trees, but as a rule they build open nests in bird houses, electric-light hoods, cornices, waterspouts, and similar places. While it is often difficult to reach nests with the hand, they can usually be torn down by means of a long pole having an iron hook at the tip. By a concerted and continued movement to destroy every nest after the eggs are laid, English sparrows in any locality may be gradually reduced without resorting to shot or poison.

METHODS OF DESTRUCTION.

AT NESTS.

The sparrow's habit of nesting in cavities can be turned to account against it. By providing one-room bird houses, or even packing boxes or tin cans, and putting them in trees or on poles or buildings at a height of about 10 feet, the birds may be captured after dark with the aid of a long-handled net. This net should have a deep bag and a small hoop made to fit the front of the boxes closely. After the net has been quietly placed over the entrance, a few raps on the box will send the tenant into it. Dilapidated buildings may sometimes be fitted up for catching sparrows in this way, as well as for destroying their nests and eggs. Figure 2 shows how this can be done. An ordinary wooden box may be nailed to the inside of the building over a hole made to admit the sparrows. The box should be arranged so that the top or upper part of the back can be lifted to gain access to the inside.

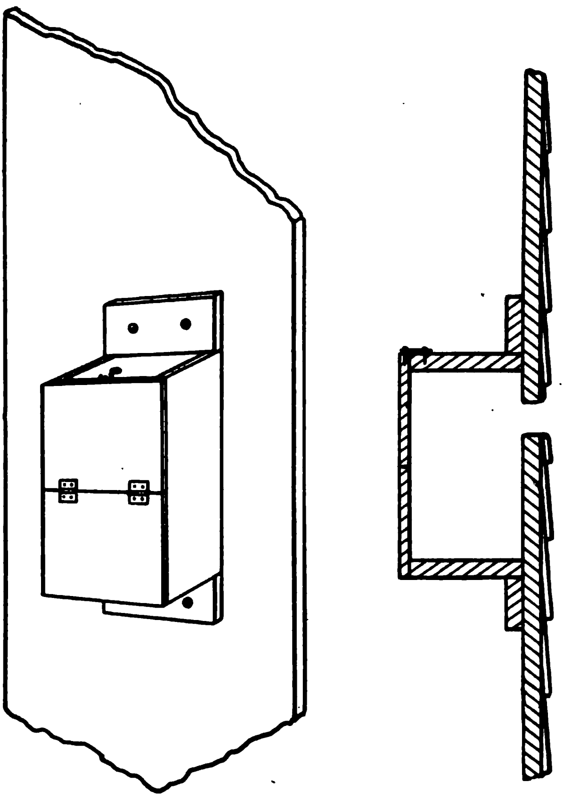

Fig. 2.—Perspective and sectional drawings of an improvised nesting box for the interior of buildings.

The box illustrated in figure 3 is designed to be hung on a building or a tree. Its floor should be about 6 inches square and its height at the eaves about 8 inches. The roof should be hinged at the top for removing the eggs or young. Such boxes may be built of rough boards at slight cost. By distributing a number of them about orchards, shade trees, and outbuildings, and catching the sparrows that occupy them, or by destroying eggs, the work of extermination may be carried on at a season when other methods are least effective.

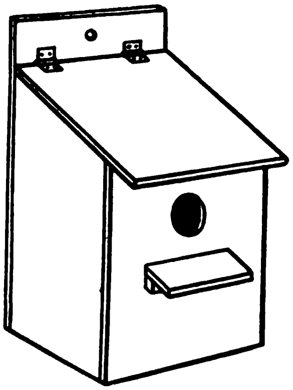

Fig. 3.—An inexpensive nest box for English sparrows.

BAITING.

Preliminary to the following destructive measures, sparrows should be baited until they are attached to the spot selected for their execution. Seeds, grain, or waste from the table, if supplied regularly, will soon establish a feeding place. If a general campaign is to be undertaken, enough such feeding places should be maintained to attract to them practically all the English sparrows in the neighborhood. This can easily be done in winter when food is scarce. After thus baiting the sparrows they may be trapped, shot, or poisoned.

TRAPPING.

Traps alone are inadequate to exterminate sparrows, but a reduction of numbers can be effected by using a shallow box not less than 4 feet square, open on one side and covered with woven wire on the other. One side of this trap rests on the ground, while the opposite side is supported by a stick 18 inches long. Near the upper end of this stick is attached a long cord, and between the top of it and the edge of the trap (see fig. 4) is placed a chip. By setting the trap over bait and pulling the cord from a sheltered point of observation when a flock of sparrows is beneath it, numbers of them may be caught. Instead of the box described above, by which the birds are taken alive, an old door or similar device may be employed as a deadfall. In either case the trap should be kept set and baited until the sparrows are not afraid to go under it. The best time for trapping is just after a snowstorm, when the birds have been fasting. Then, if the ground be cleared and chaff and grain be put under the trap, the birds will crowd in and enable the trapper to secure nearly all of the local flock. If any escape they will spread the fear of traps, and before long very few of the birds can be induced to go into one.

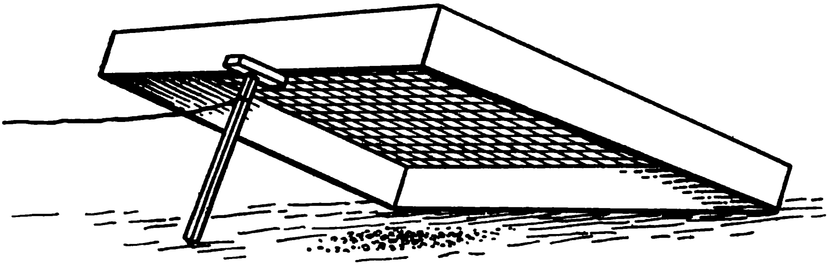

FIG. 4.—A sparrow trap.

SHOOTING.

Sparrows are accustomed to feed in close flocks, and when thus assembled a large number can be killed by a charge of No. 10 shot. The best way is to scatter grain over long, narrow areas and shoot the sparrows at these baiting places. Where sparrows infest poultry yards, the bait may be placed on a horizontal board, supported at such an elevation that the birds can be shot without danger to the poultry.

UTILIZATION OF SPARROWS FOR FOOD.

Since English sparrows are a pest and a reduction of their numbers is important on economic grounds, there would seem to be no reason why the birds, when trapped or shot, should not be utilized for food in this country, as they have been in the Old World for centuries. Their flesh is palatable and nutritious, and in city restaurants they are often served under the name of reed birds.

POISONING.

Where the use of poison is not prohibited by law, it may be effectively used to reduce the number of sparrows. Of the different poisons tested, the most satisfactory is strychnia sulphate. It is easily prepared and acts quickly. Wheat has proved to be a good bait, as well as an excellent vehicle for administering the poison. The grain should be regularly supplied at the baiting stations until the birds have become accustomed to resort to the place. A good time to put it out is early morning, as the birds are sure to be hungry for breakfast. The capacity of the sparrow's crop and stomach is about 30 kernels of wheat, varying more or less according to the size of the kernels. In deciding the amount of poisoned wheat to put out at one time, it is well to estimate the number of sparrows frequenting a feeding place and to allow about 20 kernels for each sparrow. Although 2 kernels of wheat coated with the solution described below have been known to kill a sparrow, 6 or 7 kernels are required to insure fatal results. Only as much poison should be put out as is likely to be eaten in one day, as exposure to moisture reduces its virulence. Furthermore, sparrows that take less than a fatal quantity, or that become frightened by the death of comrades, will forsake a feeding place if poison is kept there constantly. It is better, therefore, to supply unpoisoned wheat after each poisoning until the birds have recovered confidence. An important advantage in having several feeding grounds is that they may be used in rotation, the sparrows forgetting their fear of one while the others in turn are receiving poison.

A poison mixture that has proved very effective is prepared as follows: Put one-eighth ounce of strychnia sulphate into three-fourths of a gill of hot water and boil until dissolved. Moisten 1½ teaspoonfuls of starch with a few drops of cold water, add it to the poison solution, and heat till the starch thickens. Pour the hot poisoned starch solution over 1 quart of wheat and stir until every kernel is coated. Small-kerneled wheat sold as poultry food, if reasonably clean, is preferable to first quality grain, being cheaper and more easily eaten by the sparrows. A 2-quart glass fruit jar is a good vessel to mix in, as it is easily shaken and allows the condition of the contents to be seen. If the coated wheat be spread thinly on a hard, flat surface, it will be dry enough for use in a short time. It should be dried thoroughly if it is to be put into jars and kept for future use. Dishes employed in preparing poison may be safely cleansed by washing.

The poison should be well scattered, so that many birds may be able to partake at the same time, since after a few are affected their actions excite the suspicion of their comrades. Usually a few sparrows get only enough strychnine to paralyze them for a few hours, after which they recover. It is important, therefore, to visit the feeding places two or three hours after distributing poison to prevent such birds from escaping. It is well also to remove dead birds promptly to avoid exciting the suspicions of those that are unaffected. In northern latitudes the best time to put out poison is just after a snowstorm, when other food is covered. The feeding place should be cleared of snow and the poison laid early in the morning.

Sparrows should be baited in secluded places, safe from interruptions and where doves and poultry are not endangered. Roofs, back yards, and unused poultry runs are favorable situations. Proximity to low trees, grape arbors, and similar retreats has the advantage that sparrows go to such places between meals, and many dead birds will be found there well away from the bait. If undisturbed, poisoned birds will usually be found within a few feet of where the bait was spread, death occurring in from three to twenty minutes. Where doves or poultry are likely to be poisoned, the sparrows, after being baited, may be induced to feed in small covered pens made of coarsely meshed wire netting and having the sides raised about an inch and a half above the ground. There is practically no danger that cats or other animals will die from eating sparrows that have been poisoned. Any wheat coated by the above process, which is overlooked by the birds, will become harmless after a few rains.

Sparrows can be reduced locally to almost any desired extent by the methods outlined in this bulletin, but it should not be forgotten that such reduction can be made permanent only by systematic and continued efforts.

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1236 Issued April 4, 1910.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 384.

Experiment Station Work,

LV.

Compiled from the Publications of the Agricultural Experiment Stations.

POULTRY MANURE.
EARLY ONIONS IN THE SOUTHWEST.
OLEANDER POISONING OF LIVE STOCK.
FERMENTED COTTON-SEED MEAL FOR HOGS.
WINTERING FARM WORK HORSES.
ALFALFA MEAL AS A FEEDING STUFF.
MANGELS FOR MILCH COWS.
RECORDS OF DAIRY HERDS.
SKIM-MILK BUTTERMILK.
WHIPPED CREAM.
FARM BUTTER MAKING.
CAMEMBERT CHEESE MAKING.
CEMENT AND CONCRETE FENCE POSTS.

NOVEMBER, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

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- College Station: *West Raleigh;* C. B. Williams.[a]
- State Station: *Raleigh;* B. W. Kilgore.[a]

NORTH DAKOTA—*Agricultural College:* J. H. Worst.[a]

OHIO—*Wooster:* C. E. Thorne.[a]

OKLAHOMA—*Stillwater:* J. A. Craig.[a]

OREGON—*Corvallis:* J. Withycombe.[a]

PENNSYLVANIA—
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PORTO RICO—*Mayaguez:* D. W. May.[b]

Rhode ISLAND—*Kingston:* H. J. Wheeler.[a]

SOUTH CAROLINA—*Clemson College:* J. N. Harper.[a]

SOUTH DAKOTA—*Brookings:* J. W. Wilson.[a]

TENNESSEE—*Knoxville:* H. A. Morgan.[a]

TEXAS—*College Station:* H. H. Harrington.[a]

UTAH—*Logan:* E. D. Ball.[a]

VERMONT—*Burlington:* J. L. Hills.[a]

VIRGINIA—
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- *Norfolk:* Truck Station, T. C. Johnson.[a]

WASHINGTON—*Pullman:* R. W. Thatcher.[a]

WEST VIRGINIA—*Morgantown:* J. H. Stewart.[a]

WISCONSIN—*Madison:* H. L. Russell.[a]

WYOMING—*Laramie:* J. D. Towar.[a]

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EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

POULTRY MANURE.[b]

It is believed that the following brief summary of information on the preservation and value of poultry manure prepared by F. W. Morse, of the New Hampshire Station, will be of general interest:

> As is well known, when the poultry droppings accumulate under the roosts and when they are left in barrels there is a strong odor of ammonia noticeable. The development of such an odor is a sure sign that gaseous ammonia is escaping into the air to be lost for the present. How to prevent such a loss is to prevent the development of the odor. Several chemicals of more or less fertilizing value in themselves may be added to the droppings from time to time with good effect, both in stopping waste and in making the atmosphere of the henhouse more wholesome.
>
> The best materials for this purpose are gypsum or land plaster, acid phosphate, and kainit, a cheap potash salt. Each of these chemicals has the power of forming new compounds with the ammonia as fast as it is set free from the original combination. Wood ashes and slaked lime should never be used, because they can not combine with ammonia while they do force it out of its compounds and take its place.
>
> Plaster is apt to produce a dry, lumpy mixture when used in large enough quantities to arrest the ammonia, while kainit and acid phosphate produce the opposite effect of a moist, sticky mass.
>
> In Bulletin 98 of the Maine Experiment Station[c] is described an experiment in which sawdust was used in addition to the chemicals. By this addition of an absorbent, the kainit and acid phosphate could then be used with excellent results.
>
> Using their results as a basis for calculation, the weekly droppings of a flock of 25 hens, when scraped from the roosting platforms, should be mixed with about 8 pounds of kainit or acid phosphate and a half peck of sawdust. If one desires a balanced fertilizer for corn and other hoed crops, a mixture of equal parts of kainit and acid phosphate could be used instead of either alone.
>
> Good dry meadow muck, or peat, would be equally as good as sawdust, if not better, to use as an absorbent.
>
> In the experiment mentioned more than half of the ammonia was lost in hen manure without chemicals, when compared with that which had been mixed with them.
>
> Fresh poultry manure at the present values of fertilizers would be worth 60 cents per hundred pounds. Figures from different experiment stations would give the product of 25 hens for the winter season of six months as 375 pounds from the roost droppings only.
>
> Poultry manure is especially adapted as a top dressing for grass because of its high content of nitrogen in the form of ammonia compounds, which are nearly as quick in their effect as nitrate of soda. A ton of the manure preserved with sawdust and

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from New Hampshire Sta. Rpts. 1907–8, p. 550.

[c] U. S. Dept. Agr., Farmers' Bul. 210, p. 5.

chemicals would be sufficient for an acre, when compared with a chemical formula for top dressing.

On the same basis of comparison, 100 fowls running at large on an acre should in a summer season of six months have added to its fertility the equivalent of at least 200 pounds of sulphate ammonia, 100 pounds of high-grade acid phosphate, and 60 pounds of kainit.

EARLY ONIONS IN THE SOUTHWEST.[a]

The work of the Arizona, New Mexico, and Texas experiment stations has shown that the raising of onions, particularly for the early market, may be made extremely profitable in certain parts of the southwestern United States. In warm valleys where the winter conditions are favorable to growth and with proper methods of culture, fertilizing, and irrigation, large yields of very early onions can be produced which command high prices both in local markets and when shipped to distant markets.

E. L. Crane and R. H. Forbes, in a recent bulletin of the Arizona Experiment Station, state that onions are very successfully grown as a winter crop in the warmer southwestern valleys. "Planted at the close of hot weather, the crop grows during the cool months when labor is most effective, and early varieties mature in time for high prices in mining and coast towns."

The New Mexico Station reports yields of from 26,000 to 40,000, and in one case 60,000 pounds per acre, of early onions, with liberal applications of nitrate of soda. As high as 27,000 pounds per acre were obtained at the Texas Substation at Beeville. Such yields are probably considerably higher than the average that may be expected under ordinary culture. The Arizona Station gives 8 tons per acre as a common yield in the region of Yuma, with a cost of production of about $170 per acre. This agrees closely with the figures for average yield and cost suggested by Beattie of the Bureau of Plant Industry of this Department.

The profits depend not only on skill in growing and yield, but also upon prices and marketing facilities. In 1907, with a good yield and prices ranging from 2 to 5 cents a pound delivered at Yuma, 1.2 acres of White Bermudas netted about $400 after deducting all costs, including labor. In 1908, with increased costs and decreased yields due to onion thrips and mildew, with a late season, demoralized markets, and poor shipping arrangements, the crop was grown at a loss.

The lighter loam soils are considered preferable for onion culture on account of the greater ease and less cost of preparing the soil and cultivating and harvesting the crop. The soil should be abundantly supplied with organic matter, which may be chiefly added in the form of well-rotted barnyard manure. Soils containing much alkali should not be chosen, especially if ridge culture is followed, because this system of culture favors a surface accumulation of soluble salts around the plants. Flat culture with flood irrigation or ridge culture with furrow irrigation may be followed.

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[a] Compiled from Arizona Sta. Bul. 60, p. 451; New Mexico Sta. Bul. 52; Rpt. 1908, p. 27; Texas Sta. Bul. 115. See also U. S. Dept. Agr., Farmers' Bul. 354.

The flooding method is more applicable to heavy soils; but ridges and furrow irrigation are preferable for light soils which work easily and subirrigate readily.

For ridge and furrow culture the field should be perfectly level and laid off for rows from 100 to 500 feet long. This arrangement will permit of equal and sufficient irrigation without loss of water or flooding the rows. Just before planting time the ground is again irrigated, and when sufficiently dry is disk and drag harrowed to secure perfect surface pulverization. To fertilize the field open out double furrows 30 inches apart, throwing the two furrow slices in opposite directions and manuring to a depth of 4 inches in the furrows. Then plow in to form ridges over the manure. These ridges may be conveniently finished by dragging them lengthwise with a long weighted plank drawn by a horse. This will leave flat-topped ridges about 24 inches wide on top, with furrows about 6 inches wide and deep between. Thus prepared the soil may be more easily kept in tilth and weeds controlled, than in flat culture. * * *

The best and cheapest method is to sow the seed in beds and transplant later to the field. As soon as hot weather abates (usually in September), the seed is thickly sown in drills 5 inches apart in beds of well fertilized soil. The water furrows must be placed at intervals suitable for subirrigation. Two pounds of seed thus planted will provide young onions enough for an acre. If the soil is moist when the seed is planted, the seedlings should begin to appear in about nine days. An irrigation will then bring the whole stand up quickly, and with proper irrigation and cultivation thereafter the young onions will be as large as slate pencils in nine or ten weeks and ready to transplant, usually in December.

It is very important that the seed should be fresh.

The ridges having been prepared just in advance of planting, the young onions are lifted as needed, the roots trimmed to about an inch in length, and the tops cut back about half. The rows are best laid out along the ridges by means of Crane's marker. This is a round cottonwood log 2 feet long and 10 to 12 inches in diameter, with three rows 9 inches apart of pegs extending around the roller. The pegs should be about 1½ inches long and spaced at 4 to 6 inches, according to distance desired between onions. By means of a light frame tacked to the ends of the roller the marker is drawn along the ridge, leaving three perfectly uniform rows of holes. The trimmed plants are then dropped one at each hole, set about 1½ inches deep, and the soil firmly pressed about them by hand. It is then well to irrigate them lightly to insure an even start of all the plants. By this plan about 120,000 onions an acre may be placed, planting 5 inches apart in the row, with three rows to each ridge.

If the ground has been well prepared and ridges and furrows carefully constructed, the labor of irrigating and cultivating onions is not excessive. For the sandy loam of the Yuma trial ground about fifteen irrigations are required from September to April in seed beds and field. Irrigation should be followed by cultivation both in furrows and on ridges to kill weeds, lessen evaporation of soil moisture, and break up the salty crust which in most arid soils tends to form on interirrigated ridges. * * *

In order to reach the early markets in April and May it is essential, planting seed in September, to use the earliest varieties of onions, inasmuch as they require between seven and eight months, including the winter season, to mature.

The Arizona Station has found the White Bermuda the most successful variety at Yuma, although Red Bermuda and Crystal White Wax have also given good results.

These are all mild early onions and good producers, but must be sold promptly, as they do not keep long. The superior appearance of the Crystal White Wax brings it a somewhat higher price than the Bermudas, compared with which, however, this variety is a little later and a poorer keeper. New White Queen produced a good test crop of large late onions in 1906. The El Paso and the Prizetaker are very uncertain yielders under Colorado Valley conditions, while Louisiana Creole and Australian Brown have thus far produced tops only and no onions. At higher elevations, however, near Tucson and in Graham County, Australian Brown is a good producer and keeper.

The White and Red Bermudas were grown with success at the Texas Station. The New Mexico Station found Early White Queen, Barletta, White Bermuda, and Extra Early White Pearl quite satisfactory for early ripening. They are mild onions of good keeping quality. Red Victoria gave the best yield on unfertilized soil at this station.

In the Arizona experiments downy mildew often proved troublesome, but was held in check by spraying with Bordeaux mixture as soon as the mildew appeared. Thrips frequently caused considerable damage, but was controlled by spraying with strong kerosene emulsion.

As the onions attain marketable size, maturity may be hastened by withholding irrigating water and drying out the soil. To the same end also the tops may be broken over by means of a small roller. By these means three weeks may be gained in the time of ripening. The lessened yield will usually be more than made up by higher prices for an earlier crop.

Next to transplanting and cultivation, harvesting is the most costly item in connection with the crop. Flat culture onions are most costly to harvest, requiring the aid of a digging tool, especially in adobe soil. Ridge culture onions, however, if the soil is light and has been kept mellow by cultivation, may be pulled by hand, and tops and roots trimmed with a sharp knife in one operation. The trimmed onions are collected in small piles, covered lightly with grass or weeds to prevent sunburn, and left a few days to cure. If to be kept for some time, they must then be stored in thin layers or crates in a cool, shaded, well-ventilated place.

Sacks are a cheap market package, costing 5 to 10 cents for 105 pounds; but sacks allow the onions to bruise. Fifty-pound onion crates, costing 14 to 25 cents each in Arizona, are more convenient to handle, insure better keeping, and are usually demanded by the trade.

OLEANDER POISONING OF LIVE STOCK.[a]

The oleander is used as an ornamental plant in the southwestern part of the United States, while in other sections it is grown as a house plant.

That the practice of growing this shrub outdoors is attended with considerable danger to live stock is clearly brought out by F. W. Wilson in a recent bulletin of the Arizona Station. It is further pointed out that the plant is dangerous to human beings, since many persons, and especially children, are apt to chew leaves, flowers, and small sticks.

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[a] Compiled from Arizona Sta. Bul. 59.

Experiments made were with two horses, a cow, a mule, and several sheep, and included trials of green and dry leaves, flower stems, parts of the branches, bark, and roots. The material was administered in the crude dry and green form and as an infusion.

The results are summarized as follows:

> Oleanders are poisonous when eaten by * * * common farm animals. * * * The manner of obtaining the poison is generally accidental and its presence is not usually known until death is approaching. Dry leaves are poisonous as well as green leaves. There is little danger of the animal obtaining the poison from leaves in drinking water. The amount of poison necessary to cause death is small, but depends also on the condition of health of the animal. The physiological effects of oleander are similar to those of digitalis, and if enough poison is obtained the patient is sure to die.
>
> The amount of oleander necessary to cause death in horses ranges from 15 to 20 grams of green leaves and from 15 to 30 grams of dry leaves. This depends on the condition of the animal at the time the poison is obtained. A full stomach will necessitate more poison. In the case of cows it is safe to say that from 10 to 20 grams of green leaves and 15 to 25 grams of dry leaves are sufficient to cause death. For sheep the fatal dose of either green or dry leaves is from 1 to 5 grams. There is little danger in the bark, roots, or flowers, since live stock would hardly obtain sufficient poison in that way. * * *
>
> The general symptoms are increased temperature and pulse, coldness of the extremities, warm body temperature, dilation of the pupils of the eyes, and discoloration of the mouth and nostrils, followed by sore mouth. The body becomes wet with sweat, due to the exertion caused by the powerful heart stimulation. The animal generally refuses to eat or drink during the twenty-four hours preceding death. This is usually due to soreness of the mouth and throat, making it painful to masticate and swallow food. The bowels act often and feces are usually greenish in color. The action ot the kidneys is increased slightly and color of urine is normal. * * *
>
> There is little doubt that numerous cases of oleander poisoning have never been brought to light because of death being attributed to other sources. It is safe to say, however, that many hundreds of animals have been lost in southern Arizona from this shrub.

FEEDING FERMENTED COTTON-SEED MEAL TO HOGS.[a]

It is well known that the continued use of cotton-seed meal in even moderately large quantities is unsafe and frequently fatal, particularly in case of swine, but the high feeding value of the meal and its low price as compared with corn, especially in the South, has led to inquiries by a number of the experiment stations as to the cause of the injurious effect of the meal and to attempts to find practical means of using the material with safety. Some of the investigations on this subject have been referred to in previous bulletins of this series.[b]

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[a] Compiled from North Carolina Sta. Bul. 200.

[b] U. S. Dept. Agr., Farmers' Buls. 251, p. 30; 320, p. 28.

Fermenting the meal has been one of the means proposed for lessening the danger from its use, and some of the stations have experimented with the fermented meal as a swine food. The most recent report on the subject is by R. S. Curtis, of the North Carolina Station. He used fermented cotton-seed meal as a partial substitute for corn meal in experiments with young growing hogs during a feeding period of 6 months. The experiment began in January and ended in July and was divided into two periods of 3 months each, the rations being reversed at the beginning of the second period.

During the winter months it was necessary to prepare the rations from 2 to 3 days in advance of feeding, in order to have them thoroughly sour. After the weather became warm, however, 24 to 30 hours were generally sufficient to bring about the desired condition. In preparing the feeds the shelled corn and combinations of cotton-seed meal and linseed meal with corn were weighed out into tin buckets, in the proper proportions, well mixed, covered with water, and stirred thoroughly. The buckets were then placed on a shelf and allowed to stand until the rations were fed.

Four lots of 6 pigs each were used. One lot received corn alone, another 1 part of cotton-seed meal to 7 parts of corn, a third 1 part of cotton-seed meal to 4 parts of corn, and the fourth 1 part of linseed meal to 4 parts of corn.

Corn alone was found to be an undesirable ration, causing small gains and unthrift. This condition was probably more marked on account of the fact that the corn-fed pigs were closely penned without pasture, yet other lots similarly confined made relatively larger gains.

Very satisfactory results were obtained with the fermented cotton-seed meal when fed in small quantities for a limited period, the indications being that 75 to 90 days is the limit of satisfactory feeding of this material. This depends, however, on the age and condition of the hogs, the supplementary feeds, and the proportion of cotton-seed meal used.

The lot fed a combination of corn and cotton-seed meal in the proportion of 4 to 1 made larger and cheaper gains during the first 90 days than the lot fed corn and linseed meal in the same proportions. It appears, therefore, that while the cotton-seed meal used in these experiments cost about one-fourth less per ton than the linseed meal, it had a higher nutritive value, as indicated by the larger proportion of protein present.

Farmers would, according to the results of this experiment, be safe in feeding fermented cotton-seed meal to 75-pound shoats in quantities ranging from one-sixth to one-fifth the total ration, by weight, for a period of 75 to 90 days.

The feeding of the four lots of hogs during the first period was more profitable when 1 part of cotton-seed meal was added to the ration of 4 parts corn than when corn alone or corn and linseed meal in combination were fed. In case of linseed meal, however, the greater cost of gain was due to the high price of the feed, and not so much to its lack of efficiency in making gains. Barring this one factor, and the possible danger in feeding cotton-seed meal, the two feeds, according to the results of this experiment, are approximately the same in feeding value when fed for the time stated.

With corn and cotton-seed meal each costing approximately $28 per ton, the results of this experiment show clearly in favor of the combined corn and cotton-seed meal ration, considering always the limitations given as to the amount fed and length of feeding period. * * *

The practical application of these results would not be to feed under the conditions here described, but rather to feed the corn and cotton-seed meal in connection with grazing crops, which can be produced so abundantly by southern farmers. This experiment was carried on under adverse conditions to render safe conclusions possible.

When fed with judgment, cotton-seed meal can be made a valuable adjunct to corn as a ration for hogs. It is our cheapest commercial feed supplying protein, and should not be entirely ignored in swine production.

Cotton-seed meal, when fed in the quantities stated, will, after a time—100 to 120 days—apparently reduce the normal gains and profits therefrom. This point should be kept in the mind of the feeder, the amount of feed used recorded, and the hogs weighed occasionally. Accurate judgment will direct when to eliminate the meal from the ration. Aim to feed under the limit, however, rather than over.

In experiments at the Texas Station, previously noted, the results indicated that fermented cotton-seed meal, at the rate of not more than one-fourth of the total weight of the grain ration, could be fed longer without bad effects than unfermented, and that the use of green feed still further lessened the danger.

While the experiments which have been made indicate that cotton-seed meal, either fermented or unfermented, can be profitably used as a hog food under certain conditions and restrictions, still the use of the meal is accompanied by some uncertainty as to the final effects, indicating that the conditions under which the meal can be fed with absolute safety are not yet definitely determined.

It is quite evident from the experiments reported that while fermenting may lessen the danger from the use of cotton-seed meal as a hog feed, it does not entirely remove it.

WINTERING FARM WORK HORSES.[a]

In the Northern States the farm work horses have comparatively little to do during the winter months unless some special work is done; if they are fed on high-priced feeds, such as oats and timothy hay, they "eat their heads off." On the other hand, it is desirable to keep them in condition so that they will be ready for the hard work of the spring.

H. W. Norton, jr., of the Michigan Station, has started a series of experiments "with a view toward formulating more economical rations suitable to maintain horses in good flesh during the season of the year when work is light."

The results of the first year's work are reported in a recent bulletin of the Michigan Station. Twelve horses were used in the test, 6 of which received the regular ration of timothy hay and oats. The others were fed a cheaper ration máde up of shredded cornstalks, oat straw and hay for roughage and ear corn, oats, and a mixture of dried beet pulp, bran, and oil cake; carrots were also fed daily to the horses receiving the cheaper ration. The mixture was made up of 4 pounds of dried beet pulp, 1 pound of bran, and 1 pound of oil cake.

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[a] Compiled from Michigan Sta. Bul. 254.

The morning feed was 5 pounds of oat straw, 4 pounds of carrots, and 3 pounds of ear corn; the noon feed was 4 pounds of timothy hay and 2 pounds of oats; and the night feed was 8 pounds of shredded cornstalks, 4 pounds of carrots, and 2 pounds of the mixture described above.

> In feeding these substitute feeds it was thought best to provide a variety, as none was as palatable as the regular hay and oats ration. The stalks and oat straw were eaten fairly well after the first few days. The carrots seemed to be relished by all the horses. * * * The feed mixture of beet pulp, bran, and oil cake was eaten well in most cases; sometimes, however, the oil cake was left.

The conditions under which the test was undertaken prevented feeding team mates the different rations, but all the horses were doing work of practically the same kind and amount.

It was found that for the ten weeks during which the test was carried on the average daily cost per horse, based on average prices, was 19.4 cents for the regular ration and 12.3 cents for the cheaper ration; the average daily saving from the cheaper ration was 7.1 cents per horse. The horses fed the cheaper ration made an average gain in weight of 14 pounds during the period, while those fed the regular ration lost an average of 11 pounds in weight. This may be partly due to the fact that the horses fed the cheaper ration did about 8 per cent less work than the others. A further advantage of the cheaper ration is that it makes use of roughage that has little market value.

The experiment will be continued under conditions making possible a more exact comparison, and the elimination of individual variations.

It is suggested that a small part of the cornfield could be used to raise a supply of corn fodder; "the corn is grown in drills thick enough to produce moderate-sized stalks, an abundance of leaves, and from one-half to two-thirds of a crop of ear corn, the whole to be in bundle form."

ALFALFA MEAL AS A FEEDING STUFF.[a]

The value of alfalfa hay as a stock feed is now generally recognized. Within the past few years considerable alfalfa hay has been ground into a meal and offered as a substitute for grain for horses, cattle, sheep, swine, and poultry. Though sometimes sold on the market just as it is ground, it is more commonly mixed with molasses, corn chop, wheat screenings, chaff, weed seeds, or other waste products. The advantages of alfalfa meal lie in the fact that it is fed with less waste than hay and has a higher percentage of protein than ordinary hay (about 15 per cent as compared with about 6 per cent in timothy hay). It is in a convenient form for special purposes, such as city trade, and there is a considerable reduction of freight charges when shipped to a distance; but a pound of alfalfa hay does not contain any more nutrient when ground into meal than it did before, and for home consumption it is doubtful if the advantages are enough to pay for the grinding.

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[a] Compiled from Massachusetts Sta. Rpt. 1908, p. 158; Pennsylvania Sta. Buls. 80 and 81; Vermont Sta. Rpt. 1906, pp. 302 and 356; U. S. Dept. Agr., Bur. Anim. Indus. Circ. 86; U. S. Dept. Agr., Farmers' Bul. 339; North Carolina Dept. Agr. Circ. 1.

The value of alfalfa meal has been widely advertised, and many expensive plants have been installed for the purpose of grinding alfalfa hay to meal. This is an expensive operation and it is doubtful whether the benefit derived from it justifies the purchaser in paying the increased price of the ground material.

It is the purpose of this article to summarize the results of investigations made since the previous reports on this topic.[a] At the Pennsylvania Experiment Station alfalfa meal or finely ground alfalfa hay was compared with wheat bran, pound for pound. The test was made with 10 cows divided into two equal lots. The feeding covered four periods of three weeks each. The wheat bran was fed to both lots during the first and fourth periods, to lot 2 during the second period, and to lot 1 during the third period. The alfalfa meal was fed to lot 1 during the second period and to lot 2 during the third period. All other conditions were uniform for both lots.

The protein content of the alfalfa meal was 15.48 per cent and of the wheat bran 16.95 per cent. The alfalfa meal was eaten less readily than the wheat bran and produced a decrease in the yield of milk. With alfalfa meal at $23 per ton and wheat bran at $20 per ton, the prices prevailing in central Pennsylvania, the cost of grain for 100 pounds of milk when the cows were fed alfalfa meal was 47.1 cents and when fed wheat bran 45.3 cents. With wheat bran at $20 per ton the alfalfa meal was apparently worth only $21.28 per ton.

It is stated that in general—

> Grinding adds comparatively little to the digestibility of the feed for healthy animals. It may even tend to detract from it, as the ground feed is more apt to be swallowed without chewing and mixing with the saliva. It is an expensive process, particularly where it is necessary to haul the grain some distance to the mill and pay from one-eighth to one-sixth toll. With corn at 50 cents per bushel, one-eighth toll amounts to 12½ cents per hundredweight, or $2.55 per ton. * * * Some millers charge a flat rate of about $2 per ton, varying with the kind of grain to be ground. This is usually more equitable and more economical. To this cost must be added the expense of hauling the grain to the mill and returning the feed. Where much grinding is to be done, it pays the farmer to own his mill.

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[a] U. S. Dept. Agr., Farmers' Bul. 259, p. 22.

At the Vermont Station—

An alfalfa-meal ration made less milk and butter, carried less fertilizing value, and was fed at a loss, as compared with a wheat-bran ration, the meal costing $27 and the wheat bran $18.50. Had each cost alike, the former would still have been outclassed. An alfalfa-meal ration made one-seventh less milk, one-sixth less butter, and the ration containing it carried one-sixth less plant-food value than did one containing distillers' dried grains. It is utterly outclassed at equal prices.

At the Massachusetts Station with new milch cows a supplementary ration of bran gave slightly superior results to one of alfalfa meal. With the bran ration the cows gave 1.6 per cent more milk and 3.1 per cent more butter.

The several feed stuffs were figured at the same price per pound, excepting the wheat bran and alfalfa; the former cost $22 and the latter $30 a ton in the market. On this basis the alfalfa ration would increase the cost of milk and butter some 9 per cent. If the bran and alfalfa were figured at the same price a ton, the food cost of the product would vary very slightly. * * * Owing to the excess of fertilizer ingredients, especially nitrogen, in the wheat bran, the bran ration would furnish a somewhat richer manure. This fact should not be entirely lost sight of in comparing the merits of the two feeds.

MANGELS FOR MILCH COWS.[a]

In this country root crops have never been utilized as a stock feed so extensively as in European countries, but they are fed to some extent by many farmers, and some experiments have been undertaken to compare the feeding value of different roots with other feeding stuffs. It is the purpose of this article to summarize the results of experiments in feeding mangels to dairy cows.

In experiments at the Iowa Station more milk was obtained from mangels than from sugar beets, red table beets, or turnips, but the fat percentage of the milk was lower on the mangel than on the turnip ration. When roots were replaced with their equivalent in dry matter of wheat bran, the yield of milk fat decreased, and more pounds of dry matter were required to make a pound of milk fat. In some Ontario experiments mangels were found equal to sugar-beet pulp as a milk producer. At the Pennsylvania Station sugar beets and mangels appeared to be inferior to silage as a feed for the production of milk and milk fat. At the Ohio Station the feeding of beets to milch cows increased the consumption of other feeds and of total dry matter. There was an increase in the yield of milk, yield of milk fat, and in the live weight of the cows, but the gains were not enough to offset the additional cost of feed. At the Massachusetts

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[a] Compiled from Iowa Sta. Bul. 32, p. 408; Massachusetts Sta. Rpt. 1892, p. 153; New York Cornell Sta. Bul. 268; Ohio Sta. Bul. 50; Rpts. 1889, p. 89; 1890, p. 153; Pennsylvania Sta. Bul. 26; Rpt. 1894, p. 3; Vermont Sta. Rpt. 1895, p. 203; Ann. Rpt. Ontario Agr. Col. and Expt. Farm, 29 (1903), p. 74.

Station, with 40 pounds of mangels in the ration, cows gave less milk and cream than when they were replaced with 30 pounds of silage, and it cost more to raise the mangels than to make silage; but these results were not comparable when figured on a dry-matter basis, as the mangel ration contained only about one-half as much dry matter in the succulent part of the ration as did the silage ration.

The Pennsylvania Station reported that the cost of growing, harvesting, and storing an acre of beets was more than double the amount required for an acre of corn, charging each crop the same rent for land and the same amount for fertilizers. As much digestible organic matter was produced in 1 acre of corn as was obtained from 1.91 acres of mangels and 2.05 acres of sugar beets. In the feeding experiment, the silage ration made more gains in live weight and in milk production than the beet ration per 100 pounds of digestible dry matter.

At the Vermont Station 100 pounds of dry matter, both in the entire ration and in the experimental part of the ration, gave slightly greater returns when silage was fed than when it was replaced by beets, the dry matter in the silage making 1 per cent more milk and total solids and 4 per cent more fat. These differences are too small to be very important, and in these tests it may be considered that the dry matter of each fodder had about equal feeding value. The beets cost more to grow, harvest, and store, and at best produced no more and no better milk. On the other hand, beets were much liked by the cows and promoted their general health and digestion, and therefore it was thought that they might serve a useful purpose as an appetizer, particularly if no other food of a succulent nature were at hand.

In some recent experiments at the Cornell Station, 1 pound of dry matter in mangels was found to be equal in feeding value to 1 pound of dry matter in the grain, and a little more than equal to 1 pound of dry matter in silage, but the cost of milk production was higher on the mangel than on the silage ration. The total dry matter required for the production of 1 pound of milk fat on hay, grain, and silage was 22.34 pounds, on a hay, grain, and mangel ration 20.93 pounds, and when mangels and silage were substituted for one-half of the grain ration, 22.02 pounds. The average cost of production of a pound of milk fat on the three rations was 20.7, 27.4, and 20.7 cents, respectively.

Accepting the average price of commercial feeding stuffs at $30 per ton, and considering 1 pound of dry matter in mangels equal to 1 pound of dry matter in grain, mangels may be used economically in the ration to replace one-half the grain ordinarily fed when they can be produced and stored ready for feeding at $4 per ton. In arriving at this conclusion, the average amount of dry matter in grain is considered to be 90 per cent and in mangels to be 12 per cent. It would seem to be a safe assumption that farmers can raise mangels for $4 per ton, and thus reduce their feed bill very materially by the judicious use of mangels to replace one-half of the grain ordinarily fed in the ration.

Experiments on growing mangels and other roots are reported in a previous bulletin of this series.[a]

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[a] U. S. Dept. Agr., Farmers' Bul. 309, p. 7.

RECORDS OF DAIRY HERDS.[a]

Many farmers in all parts of the country find dairying to be the most profitable branch of their business, but many cows are kept at an actual loss, and one of the chief reasons is because the farmer has not realized the importance of keeping yearly records of the milking capacity of each cow. Recent investigations at the experiment stations bring to light some very interesting facts which illustrate the importance of keeping records.

In an Idaho herd of 10 cows the average profit per cow for the year was $21.73. On dividing the herd into two groups according to profit, the 5 best cows returned a profit of $36.34 each and the 5 poorest cows a profit of $7.12 each. Thus, if at the beginning of the year the 5 poorest cows had been dropped from the herd the average profit per cow would have been $36.34 instead of $21.73.

The Tennessee Station, in cooperation with the Bureau of Animal Industry of this Department, made a study of 12 herds. One herd of 20 cows produced an average of 5,974 pounds of milk and 307.5 pounds of milk fat per cow per year, an income of $1,845, or an average of $92.25 per cow, estimating milk fat to be worth 30 cents per pound. The poorest herd, which contained 37 cows, produced on an average 4,233 pounds of milk and 177.8 pounds of milk fat per cow, making a gross income of $1,974.33, or $53.36 per cow. If these cows had averaged as high as the other herd the owner would have made $1,438.93 more during the year.

The best cow in the 12 herds, comprising 298 cows, produced 8,087 pounds of milk and 410.94 pounds of butter fat. It cost $36.96 to feed this cow, which makes the butter fat cost a little less than 9 cents per pound, so that the cow makes a profit on butter fat alone of $86.32 during the year. Compare with this the record of the poorest cow. She produced only 1,680 pounds of milk and 65.30 pounds of butter fat, at a cost of [nearly 37] cents per pound, or a total of $24.14, which results in the loss of $4.55 for the year.

At the Connecticut Station a study was made of 5 typical herds.

Herd No. 1 has an average production for all cows kept in the herd for one year, of 7,567 pounds of milk with an average fat test of 4.4 per cent. The number of cows producing this average amount was 36. It should be noted that one reason for this high yearly average is the fact that a large number of cows were used from which to select the 36 that finished a full year; the total number in the herd for the year being over 70. The average cost of feeding these cows was $74.80 per year, and the average net profit was $32.98 per cow.

The averages for herd No. 2 were somewhat lower, being 6,388 pounds, but with a higher fat test of 5.4 per cent. The cost of feeding herd No. 2 was some $4 per year per cow less than No. 1, being $70.43 per year, and the net profit per cow was $15.24 per year.

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[a] Compiled from Connecticut Storrs Sta. Bul. 57; Idaho Sta. Bul. 67; Tennessee Sta. Bul. 83. See also U. S. Dept. Agr., Farmers' Bul. 273, p. 21.

Herd No. 3 gave an average yield of 6,771 pounds of milk per year testing 3.5 per cent fat. The cost of feeding was lower than either No. 1 or 2, being $67.94, and the net profit per cow was $24.99.

Herd No. 4 gave an average yield of 7,164 pounds of milk, with a fat test of 3.6 per cent. The cost for feeding this herd was higher than for any other, being $82.50 per cow. This high cost was brought about by lack of pasture. The cows were fed silage and grain a greater part of the summer and the cost was more than for pasture. The average net profit per cow was $17.72.

Herd No. 5 has made a poor showing for the nine months it has been tested. The amount of milk given is very low. Two thousand six hundred and seventeen pounds for nine months would mean only 3,489 pounds for a year, or about half the amount given by the other herds. The cost of food for the nine months is low, being only $42.93, which would amount to an average of $57.24 for twelve months.

It is worth noticing that in practically every case the cows fed the most expensive ration made the largest net profit. Wherever there was an attempt to save money by feeding a cheap ration the loss in milk overbalanced the saving in feed. It is true that herd No. 4, which had the highest average cost per year, did not have the highest net profit per cow; but that has already been explained as being due to the lack of pasture. A study of the individual cows in herd No. 4 shows that as a rule the cows using the most food gave the largest profit.

The following are samples of the rations fed daily to the various herds:

Herd No. 1 was fed 30 pounds of silage from which the ears had been removed before cutting, 8 pounds of clover hay, and 8 pounds of grain. The grain mixture was made up as follows:

200 pounds corn meal.
200 pounds distillers' grains.
100 pounds oil meal.
100 pounds cotton-seed meal.

Bran was fed to cows about to freshen, but was not generally fed to the stock on account of its relatively high price. The above ration is given for the average cow.

Herd No. 2 was fed 4 to 10 pounds of [a commercial feed] per day, according to amount of milk given, with 30 pounds of corn silage and clover hay.

For herd No. 3, the grain mixture consisted of—

200 pounds of [a gluten feed].
200 pounds of [another gluten feed].
200 pounds of hominy.
200 pounds of coarse wheat bran.
200 pounds of cotton-seed meal.
15 pounds of fine table salt.

The amount of this mixture to be given each cow was determined according to the pounds of milk she gave weekly.

Those giving 50 to 75 pounds of milk per week received 2 pounds of grain per day, and the amount was increased 1 pound of grain per day for each 25 pounds increase in milk. Thus a cow giving 275 pounds of milk per week would get 10 pounds of grain per day. The roughage consisted of 1 bushel of silage daily and all the hay that the cow would eat.

In herd No. 4, cows giving 35 to 45 pounds of milk per day, received:

40 pounds of corn silage.
10 pounds of hay.
10 pounds of grain.

The grain mixture consisted of 100 pounds of wheat bran, 100 pounds of fine middlings, and 100 pounds of cotton-seed meal. Cows giving 25 to 35 pounds of milk per day received 35 pounds silage, 8 to 10 pounds hay, and 8 pounds of grain, and cows giving 15 to 25 pounds per day, 30 to 35 pounds of silage, 8 to 10 pounds of hay, and 6 pounds of grain. * * *

All of the herds tested, except No. 5, are fine examples of the most advanced methods in dairy farming. They are very much above the average of the State, which is probably not much above 4,000 pounds per year per cow. Figuring the income from that amount on the same basis used with the herds tested, it would only amount to $74.41 for the milk, and adding $12 for the manure and calf would make a total of $86.41 per cow. * * * [The records] show that very few cows are kept for less than $110. * * *

If there exists in the State a number of such herds as Nos. 1 to 4 then in order to bring the average down to 4,000 there must be a good many such herds as No. 5.

Two things are needed to remedy what is rapidly becoming a serious situation. In the first place the dairy farmer should give more careful attention to the individual cows in his herd. He should know exactly what each one produces and what it costs to feed her, and every cow that falls below a certain standard should be weeded out. More attention should be given to careful breeding of good dairy animals. It is becoming more difficult every year to buy good cows. The price is advancing while the quality remains low on the average. The breeding up of the herd by the use of first-class, pure bred dairy sires can not be too strongly insisted upon. The dairyman should study the subject of breeding and depend largely upon his own effort to improve his herd rather than trust to buying improved cows from his neighbor.

The second point to which attention should be called is the price obtained for dairy products. The consumers of milk, butter, and cheese demand at the present time an article of superior merit. The cost of producing such an article is much greater than to produce a poor article. The consumer should be educated as to the value of a good dairy product. It will not be possible for the average cow of this State to produce 6,000 pounds of milk for many years to come. Herds Nos. 1 to 4 are exceptionally well bred and well handled; they are really a selection from the whole cow population and not an average sample.

SKIM-MILK BUTTERMILK.[a]

The buttermilk obtained in the old household methods of butter making was highly prized by many as a refreshing and healthful beverage and was considered of especial value in case of persons suffering from fevers. The modern methods of dairying now generally used yield no such product as the old-time buttermilk. There has been, however, a recent revival of interest in the nutritive and hygienic properties of buttermilk, and as a result there is an increased demand for buttermilk of good flavor and wholesome and uniform quality. Attempts have been made to find a process of preparing under modern conditions of dairying a product which would meet these requirements.

John Michels, of the North Carolina Experiment Station, describes in a bulletin of that station a method which he has successfully used for this purpose. This is in brief as follows:

As soon as the skim milk leaves the separator, whole milk is added to it at the rate of 1 gallon to 20 gallons of skim milk. This gives the mixture a fat content which approximates that of natural buttermilk. A large quantity of pure culture of lactic-acid bacteria (starter) is next added and the temperature brought to 70° F. Enough culture is added to curdle the skim milk in about six hours at the temperature mentioned. When a temperature above 70° F. is employed, there is a tendency for the skim milk to "whey off" after it has curdled.

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[a] Compiled from North Carolina Sta. Bul. 202.

When thoroughly curdled the skim milk is placed in a churn and churned for forty minutes in the same way that cream is in making butter. The churning process thoroughly breaks up the curd clots, resulting in a smooth, thick liquid which can not be distinguished from ordinary good buttermilk.

Immediately after the buttermilk leaves the churn the temperature should be reduced below 50° F. to prevent further development of acidity. Ordinary milk and cream coolers with enlarged holes in the distributing receptacle will answer very satisfactorily.

After cooling, the buttermilk should be run through a strainer consisting of one thickness of cheese cloth to remove any unbroken curd clots. As soon as strained the buttermilk is bottled or put in tin cans holding from 1 to 5 gallons, after which it is placed in the refrigerator, where it should be held at a temperature of 40° to 45° F. until ready for delivery.

Buttermilk made by this process was sold to drug stores, lunch counters, and hotels at 5 cents per quart in quart bottles and 15 cents per gallon in cans holding from 1 to 5 gallons.

In the larger cities buttermilk sells at a considerably higher price than given above. Thus, for example, the writer found that buttermilk during the past summer was furnished in bulk in Norfolk at from 25 to 30 cents per gallon. Considering both its food and tonic properties, buttermilk may be considered cheap at 10 cents per quart.

In trying to sell skim-milk buttermilk, it is necessary, in the first place, to explain that this product when made as described above is almost identical with the highest grade of natural buttermilk, both in composition and physical properties, and therefore in palatability and wholesomeness. Indeed, it is not thought possible under average conditions to secure natural buttermilk of as uniform a quality or of as fine a flavor as can be obtained from skim milk. When these facts are explained to dealers and consumers, any prejudice which might exist against this artificial product will gradually disappear.

WHIPPED CREAM.[a]

Cream is not only a delicacy which most persons relish, but is a very important food as well. It consists very largely of the fat of milk (butter fat), with some water and a little protein, carbohydrates, and mineral matter, and is one of the very valuable sources of fat in the diet, as it supplies this constituent in a palatable and readily digestible form.

The use of cream in the household with fruits, cereals, and other foods is too well known to need mention, and in such cases, as well as when an ingredient of custards, puddings, and other made dishes, it not only helps to make the dish palatable but contributes much to its nutritive value.

Its most important use, of course, is for the manufacture of butter and cheese. In recent years the manufacture of ice cream under commercial conditions has grown into a very large industry and requires great quantities of cream. It is also very largely used by confectioners as well as home cooks for making whipped cream, which finds so many uses in cookery and on the table. When cream is beaten or whipped fine bubbles form which do not break readily, and a foam results much like the beaten white of egg. Too long beating results in the separation of the butter fat and the formation of butter. A good quality of whipped cream consists of a dense foam which has sufficient body or firmness to enable it to stand up well.

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[a] Compiled from Maryland Sta. Bul. 136.

It seems fair to say that no entirely satisfactory explanation of this property of whipping has been given, though several have been offered. The question was studied some years ago at the Wisconsin Experiment Station and the results suggested that the calcium content of the cream might have something to do with it, as the addition to cream of a small amount of limewater containing sugar materially aided whipping. These experiments have been discussed in an earlier bulletin of this series.[a]

At the Maryland Station C. W. Melick has carried on recently a series of experiments to ascertain the effect of different factors on the production of whipped cream. The thickness of cream is one of the conditions generally considered important in the household and so the effect of the proportion of butter fat was studied, as well as the effect of the temperature of the cream, the amount of lactic acid present, the effect of centrifugal separation in comparison with top skimming, and the effect of pasteurization. In making whipped cream sugar and flavoring matters are commonly used, and so tests were made in which sugar, salt, vanilla, and gelatin were added, as well as junket, dried milk powder, cornstarch, egg albumen, and viscogen; that is, the solution of sugar and lime referred to above were added to the cream. The effect of the period of lactation on the whipping quality of the cream was also taken into account. In each of the experiments sample lots measuring 50 cubic centimeters were whipped with an egg beater in a porcelain mortar under similar conditions, normal sweet gravity cream being used as a standard for comparison in every case.

According to the summary of experimental data, no difference was observed in the whipping qualities of gravity and separator cream, and Professor Melick concludes that when differences are experienced in the household they are due to other factors and not to the method of removing the cream from the milk. The conclusion was reached that for whipping purposes cream should contain at least 20 per cent of butter fat, and in the experiments reported the best results were obtained when the fat content ranged from 25 to 40 per cent.

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[a] U. S. Dept. Agr., Farmers' Bul. 69, p. 23.

A low temperature was also found to be an important factor, and for the best results cream should be kept at a temperature of 35° to 45° F., for at least two hours before whipping, and then the cream should be whipped in a cool room. For good results the cream should be from 12 to 24 hours old, in order that there may be an opportunity for the development of a small amount of lactic acid in the cream.

> The addition of one-tenth to three-tenths per cent of commercial lactic acid to cream facilitated its whipping, and made it possible to whip cream which was fresher, which contained less butter fat, and which was warmer than is [otherwise] advisable for the best results.

Professor Melick states that the acid affected the gelatinous consistency of the casein and albumen and thus facilitated the incorporation of air in whipping, and that when it is desired to use fresh cream the addition of three-tenths per cent commercial lactic acid serves the purpose of the acid which would develop in the cream on standing. Pasteurized cream it was found could be whipped as easily as unpasteurized if it was thoroughly cooled and held at 35° to 45° F. for at least two hours before whipping. For the most satisfactory results it was found that cream should whip in 30 to 60 seconds. When a longer time is required there is danger that some of the butter fat will separate, as in churning.

The use of viscogen facilitated the whipping of cream to a greater extent than any of the other ingredients, it is stated, with the exception of lactic acid.

> It proved less effective than the latter and also less effective than a low temperature. The addition of viscogen caused cream to remain sweet from 12 to 24 hours longer than it otherwise would.
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> The use of powdered sugar, powdered milk, salt, caramel, gelatin, junket, and cornstarch, each facilitated the whipping of cream to a small degree, and each to practically the same extent. None of them proved as effective as a low temperature and the development or addition of lactic acid. The addition of an excess of gelatin above 10 per cent or of cornstarch above 20 per cent caused a lumpy cream when whipped.
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> The use of egg albumen with cream when whipped separately and mixed produced a lighter foam, but had no effect upon the time required to whip. When mixed before the egg albumen was whipped, at temperatures above 40° F., the whipping was retarded.
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> The use of vanilla extract used in ordinary quantities had no effect upon the whipping qualities of cream.
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> The charging of cream with carbonic-acid gas without pressure had no effect on its whipping qualities, but caused it to remain sweet from 12 to 24 hours longer [than is otherwise the case].
>
> The use of cream from cows near the end of their lactation period whipped with slightly more difficulty than did cream from fresh cows.
>
> Whipped cream will not keep sweet as long as unwhipped cream.
>
> When any additions are made to cream to facilitate whipping it should be so labeled as to not deceive the purchaser.

The care of cream on the farm, the effect of different factors on flavor, its composition, food value, and related questions have been considered in earlier Farmers' Bulletins.[a]

FARM BUTTER MAKING.[b]

The Illinois and New Hampshire stations have recently issued publications on the subject of butter making on the farm. This feature of the dairy industry has not received much attention from the stations in recent years, owing to the rapid development of creameries and cheese factories and the great extension of the areas furnishing the milk supplies of cities.

C. E. Lee, in a circular of the Illinois Station, confines himself to practical directions for handling cream and making butter; while F. Rasmussen, in a bulletin of the New Hampshire Station, in addition to giving practical instruction along the same lines, reports the results of an inquiry into the possibilities of farm butter making in New Hampshire.

In both publications especial emphasis is put on the necessity of using great care in the production of the cream as well as in the actual making of the butter; in other words, it must be remembered "that butter of good quality can not be made from cream produced under unsanitary conditions."

This phase of the subject is treated by Professor Rasmussen as follows:

> When using the term cleanliness in speaking of butter making it means to most people simply the necessary care taken to prevent contamination during cream ripening and during the manufacture of the butter.
>
> This subject should, however, be considered under two heads: (1) Cleanliness in the production and handling of the milk and cream, and (2) cleanliness in the manufacture of the butter. The place and conditions for carrying out the operations under both of these heads vary considerably. A large part of the work under the first heading, cleanliness in the production and handling of the milk, particularly the milking and separating, is generally carried out by the men, while the churning of the cream and the making of the butter is more often done by the women. It is much more difficult to keep the place where the cows are kept and milked free from contaminating surroundings than the place where the butter is made, the former being done in the barn, the latter in the house or in a special room or building kept for that purpose. Considering this and also the fact that woman as a rule excels man in cleanliness, it can readily be seen that more often the conditions under which milking and separating took place than the conditions under which the butter is made are responsible for the poor quality of butter often made on the farm.

Several factors combine to render greater profits possible by making butter on the farm than by any other method of disposing of the product. Among the more important of these factors are the location of the farm, the size of the herd, and the possibility of a special market. Since many of the smaller creameries have been closed for various reasons it happens that numerous farms are a long distance from a creamery or shipping station and the long haul makes it unprofitable to sell milk or cream; the size of the herd is closely related to the location of the farm, since the smaller the herd the shorter the distance that it is profitable to haul milk and cream. As a matter of fact, the most important factor is the possibility of a special market for the butter made on the farm. In every village and small city it is possible for one or more farmers to find customers who are glad to get good dairy butter, and are willing to pay the top price for it. The possibilities for a special market in New Hampshire are thus discussed by Professor Rasmussen:

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[a] U. S. Dept. Agr., Farmers' Buls. 201, 241, 363.

[b] Compiled from Illinois Sta. Circ. 131; New Hampshire Sta. Bul. 141.

> Many farmers located near a town or city are able to find private customers for their butter as well as other farm products. The advantages of the special market is that a higher price as a rule is obtained for the product, as the middle man is eliminated and there is no bartering. New Hampshire, with its large city population, offers special opportunities to the farmer for finding or creating special markets for dairy products. The fact that so many city people spend part of the summer in the country, thus having an opportunity of becoming acquainted with the product of the farm, offers opportunities to the farmer for obtaining special markets which are hardly equaled outside of the New England States. The demand for uniform, good butter is greater than the supply. This does not mean that the consumers are scouring the country and offering high prices for butter, but it means that the producer can readily find a market for his product if he will search for it. First of all he must let the people know that he has butter to sell. For the man who expects to carry on a permanent business, a few dollars used in judicious advertising are as a rule well spent. The cheapest and most effective method of advertising to-day is the printed page. As the market within reach of a particular farmer is more or less local and his supply limited, an extensive system of advertising would prove unprofitable. The use of postal cards, letterheads, printed wrapping paper, advertisements in local papers, and the distribution of hand bills, are cheap and effective methods of advertising which can be used to advantage. There are a number of dairies in New Hampshire that have been successful in obtaining considerably above the average price paid for butter. This is not always accomplished in a day, but is the result of a careful and persistent study of the locality, likes and dislikes of their customers, and of their power and willingness to pay a high price for the product. It is the result of making a uniform grade of butter, having a uniform supply for the year and keeping it well advertised.

It should also be noted that in cases where the farmers deliver the butter directly to the customers, it is possible to dispose of other milk products, such as skim milk, buttermilk, and cottage cheese, at profitable prices, unless the skim milk and buttermilk are needed on the farm for feeding calves, pigs, or poultry.

The conditions noted above probably prevail to a greater extent in the Eastern States, where the population is denser and the farm smaller, but hold true to some degree in every dairy State.

The fact that farm butter making has attracted the attention of station workers in States as widely separated as Illinois and New

Hampshire seems to indicate possibilities in this direction meriting the consideration of farmers; perhaps this is more especially true of those on small farms or those engaged in what might be called a mixed type of farming. The especial point to be emphasized is that profit is only to be realized by a thorough knowledge of and careful attention to all the details that are involved in making a first-class product.

These details have been very thoroughly and plainly set forth in a previous Farmers' Bulletin.[a]

CAMEMBERT CHEESE MAKING IN THE UNITED STATES.[b]

The preliminary report on the study of this subject has been noted in a previous bulletin of this series.[c] As stated in the previous note, the work was done by the Connecticut Storrs Station in cooperation with the Dairy Division of the Bureau of Animal Industry of this Department.

In a recent bulletin of the Storrs Station Mr. Charles Thom discusses the "practical and scientific problems [that] have been found in attempting to establish the manufacture of Camembert cheese in America."

During the last few years a number of factories have been started in this country with a view to producing the Camembert type of cheese, but many difficulties have arisen, and in some cases the enterprises have been abandoned, and in no case has complete success been attained. However, the progress that has now been made in the study of the peculiar problems involved seems to warrant the belief "that a readjustment of methods to conditions will eventually bring permanent success."

The general equipment for receiving, weighing, and testing the milk; steam for heating and sterilizing; a supply of pure water; and such construction and apparatus as will insure absolute cleanliness are the same as in any well-equipped plant for handling milk. It is especially necessary to keep flies and insects out of the rooms where the milk and cheese are handled. The windows must be screened with wire netting of fine mesh in order to keep out the small flies, which are a serious pest in cheese work.

The special equipment of the making room is described by Mr. Thom as follows:

> **Tables.**—Table surface enough is demanded to accommodate the cheeses to be made in two days. These tables are variously 36 to 42 inches wide fastened in pairs

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[a] U. S. Dept. Agr., Farmers' Bul. 241.

[b] Compiled from Connecticut Storrs Sta. Bul. 58; U. S. Dept. Agr., Bur. Anim. Indus. Bul. 115.

[c] U. S. Dept. Agr., Farmers' Bul. 296, p. 31.

to the opposite sides of two vertical pillars about 32 inches above the floor. They are constructed of wood with smooth surface, sometimes of wood covered with galvanized iron. It is best not to have the wood protected with metal or any heat-conducting material. The temperature of the curd being several degrees above that of the room, the curd cools down more or less rapidly while draining, and the rate of loss of heat is increased when the curd is in contact with a cold sheet of metal. This retards draining and produces an uneven texture on account of the different rate of cooling of the top and bottom of the cheese. A raised edge on each side prevents whey from running from the table to the floor. The tables slope toward the pillars to which they are fastened and toward one end, so that a single gutter connecting their ends carries off the whey from all the tables. In most factories, directly above the draining tables and fastened to the pillars in the same way, 3 feet above the tables, are two shelves of about the width of the draining table. They are used for draining the cheese during the second and third days, when space is needed. These shelves are not used except when space is urgently needed, and often not at all.

Aisles.—The aisles between these tables should be wide enough for the maker to work comfortably. Sometimes only 26 inches are allowed, but 32 to 36 inches would be more comfortable working room.

Draining mats.—The form of draining mats is imported from France. They are made in strips, like cloth, of different widths and are bought by the roll. The matting purchased should be exactly as wide as the draining tables. It is composed of delicate wood strips held together by thread. The matting is cut into lengths convenient for handling and washing. These may be the full length of the tables unless the tables are very long.

Hoops or forms.—The number of hoops provided should be twice the number of cheeses to be made per day. The hoops used vary slightly (perhaps one-fourth inch) in diameter in different factories. They are preferably made of heavy tin, with edges turned and soldered. The hoops used in factories visited have been 5 inches high and 4⅝ inches in diameter. Each hoop is perforated with three rows of holes one-twelfth inch in diameter and about 2 inches apart in the row. Although hoops 5 inches high are regularly used, it is often necessary to fill them up after the curd has been dipped some time. When this is found to be the case, it might be desirable to make the hoops one-half inch higher. Some have used also a low hoop for draining the second day. Its use is not general and not recommended. * * *

Dippers.—The curd is transferred from curdling pans to hoops by means of long-handled dippers which are small enough for the bowl of the dipper to be lowered into the hoops.

Curdling cans.—Curdling cans are made to hold about 200 pounds of milk each. These cans are made of heavy metal and taper from about 12 inches in diameter at the bottom to 20 to 24 inches at the top. Handles at the top make these cans more convenient to move.

Trucks.—For each one or two makers dipping cheese a truck must be provided. This essentially consists of a round base with a rim perhaps one-half inch high into which the curdling cans fit readily. Under this base rollers provide easy motion in any desired direction. The height of the truck plus the height of the curdling can should bring the edge of the can very nearly to the top of the hoops when arranged upon the draining table. This will minimize the labor of dipping.

Curdling shelf.—A shelf conveniently placed should the raise curdling cans from the floor just high enough to allow them to be slid readily upon the trucks. The tables are usually placed with one end toward the windows, the aisles between and across the inner end, with curdling cans arranged on their shelf along the inner wall of the room. Arrangement is, however, a matter of convenience. Instead of a wooden shelf, sections of the concrete floor along the wall are often simply raised above the main level of the floor high enough to move the cans easily to the trucks.

Salting boards.—Boards or trays are provided for handling freshly salted cheeses while they remain in the making room. These are from three-fourths inch smooth matched lumber held together by cleats to make the boards or trays about 24 by 30 inches—large enough to carry thirty cheeses.

The temperature of the making room should be kept as near 68° F. as possible, and should not be allowed to go below 60° F. nor above 75° F. To prevent sudden changes in temperature the windows should have double sash, the inner sash being hinged and flush with the wall to prevent accumulation of dirt. The air of the room should be kept pure and moist enough so that surface evaporation from the cheeses will be slow.

The milk used should be a good clean milk, not over 18 hours old, nor excessively rich in fat; with ordinary factory milk it is recommended that not over 0.5 per cent of fat be removed.

The use of starters is advised, to reduce losses from gas and to produce a better draining cheese. It has been found that commercial starters give less uniform results than the so-called "natural" starters, but with proper care the commercial starters give the best average results. The acidity at renneting time should be from 0.20 to 0.25 per cent to give a good, smooth curd. The percentage of acidity is found "by titration to phenolphthalein of 17.6 cubic centimeters of milk with tenth-normal sodium hydroxid. The number of cubic centimeters of alkali required divided by 20 gives the percentage of acidity calculated as lactic acid."

A convenient method of measuring acidity has been described in a previous bulletin of this series.[a]

The milk should be clean and fresh enough so that a ripening period may ensue between the addition of the starter and that of the rennet without causing the acidity to exceed the maximum limit of 0.25 per cent. The organisms that produce gassy curd are apt to be present in Camembert cheese, and great care is necessary to control gas formation. These organisms are especially prevalent during the months of December to March, inclusive. It was found in the studies reported by Mr. Thom that "the introduction of 0.5 per cent or slightly more pure starter with ripening over night at 50° to 57° F. produced sufficient ripening to reduce gas formation to a minimum, without raising the acidity test above 0.22 to 0.23 per cent."

The temperature at time of renneting should preferably be 86° F., and should be not less than 84° F. nor more than 90° F. The amount of rennet is from 3 to 5 ounces per 1,000 pounds of milk, or 10 to 15 cubic centimeters per 100 pounds of milk. The larger amounts generally give firmer curds and cheese of better texture.

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[a] U. S. Dept. Agr., Farmers' Bul. 381, p. 30.

The curdling time is 1¼ to 1½ hours or longer. When it is ready to dip the curd should be quite firm and smooth, and the whey should be from 0.02 to 0.05 per cent less acid than the milk when set. Curd should not stand long after it is ready to dip. In dipping the curd should be uniformly distributed in the hoops—that is, all the hoops should have an equal amount of curd.

The cheeses are left to drain about 18 hours, usually until early the following morning, when they are turned.

Inoculation with mold spores is done just before salting, but is not necessary except when a factory is first established. In such a case it is best to procure pure cultures from a reliable laboratory. The method of application is described as follows:

> Take a small jar with a tin cover which has been punched full of small holes (or an ordinary pepper box). Fill it half full of water, add a piece of moldy cracker or a piece of cheese with a good growth of the proper mold, and shake thoroughly. The contents of the jar are now sprinkled upon the surface of the cheeses, the cheeses are then turned and inoculated in the same manner on the other side.

The salting is done when the cheeses are firm enough to handle, usually 18 to 24 hours after dipping. A coarse-grained salt is used, and it should be thoroughly dry. The amount of salt used depends on the demands of the trade to be supplied. After salting, the cheeses are drained in the making room from 24 to 48 hours. The cheeses should be solid enough when they leave the making room so that the fingers do not dent their edges when they are picked up. The cheeses when ready for ripening contain from 57 to 60 per cent of water, and when fully ripe from 47 to 50 per cent.

The ideal arrangement for ripening is to have (1) a first ripening room called a "haloir," in which a relatively high humidity is maintained; (2) a drying room or "sechoir;" and (3) a ripening cellar. In actual practice, however, the ripening is usually carried on in one room. This room should have ample ventilation and light and be provided with double windows, as specified above for the making room. The special equipment used in the ripening room is thus described:

> For ripening Camembert cheeses a particular form of shelves has been developed. The permanent part of these consists of posts from floor to ceiling of 2 by 2 or 2 by 4 lumber in sets of 4, 5, or 6 feet apart. In each group the end posts and the parallel posts of this series are connected in pairs by permanent crossbars of similar size about 1 foot apart, from floor to ceiling, nailed or bolted to the inside of the posts. Frames of strong lumber are made to fit exactly between these uprights resting on the crossbars. These frames are composed of strong side and end pieces, and lighter cross strips.
>
> Each frame is covered by a piece of coarse matting. This consists of thin round strips of wood, held 1 to 1¼ inches apart by wire strands. The cheeses lie directly upon this matting. A cheese will rest upon three or four strips so that the surface is almost entirely exposed to the air. Such frames carry about ninety cheeses each.

Two frames exactly fill the area between four posts, so that all the cheeses are within reach from the sides.

Windows well screened should provide abundant light for working in these rooms. Artificial light (aside from electric) is undesirable because it vitiates the air. There is no advantage in dark rooms because experiments with dark rooms indicate that the trouble from fly maggots is greater under dark conditions than in fairly well-lighted rooms.

Ripening boards.—Smooth boards 8 to 9 inches wide and exactly long enough to rest upon the same supports are used to replace the frames and coarse or grating-like matting in the later stages. These boards are wide enough to carry two rows of cheeses and smooth to avoid the tendency of cheese to stick to the wood. The cheeses should be removed to the boards before softening begins. If left upon the mats the strips of wood begin to cut into the ripened cheese as soon as softening commences.

The temperature in the ripening room should be from 52° to 58° F. The lower the temperature the longer the process of ripening will continue. The relative humidity should vary between 83 and 90 per cent. The best percentage of humidity is determined by the temperature and water content of the cheeses. For cheeses having a water content of 57 to 59 per cent a relative humidity of 86 to 88 per cent at 52° to 54° F. is probably best.

The description of the ripening process is summarized as follows:

First two weeks.—Cheeses are kept upon coarse matting. Conditions should be controlled to produce a moderately thin rind showing well-distributed but not heavy areas of mold interspersed with patches beginning to show reddish slime. Relative humidity must be held high enough to permit the slime to begin to show with the mold, but not so high as to prevent the appearance of the mold. Cheeses will lose probably about 3 to 6 per cent of water in this time according to the handling. Traces of softening under the rind show at the end of two weeks. Cheeses must be removed to smooth boards, or wrapped and boxed.

Third week.—Slime areas increase without other changes in appearance; softening progresses rapidly. The rate of change depends on the temperature and the percentage of water still present. Enough evaporation must be allowed to bring the softened protein to the consistency desired (commonly 50 to 51 per cent of water at the end of the time). The progress of this change can be constantly determined by feeling the cheese. Ripening of the proper texture and flavor must be well begun and the water content lowered to a safe percentage before cheeses can leave the factory with assurance of success in their further handling.

Further handling.—According to the market demand, cheeses may be boxed and their further ripening be completed in the cellars or in storage in the dealer's hands. The ripening should not be complete before the end of the fourth week and may often desirably be lengthened considerably beyond the fourth week. The progress sought can be controlled to a large degree by controlling the temperature of the storage room, or ripening cellar if one is used. If cheeses have the proper consistency at the end of the third week, proper care alone should assure good results in the further ripening. This responsibility falls upon the dealer or consumer.

The construction of ripening rooms on the plan of those used in France has not proved a success except for the months of September, October, and November, when the climatic conditions of the eastern part of this country more nearly approach those of the Camembert producing sections of France. It is necessary, therefore, to adopt construction to "provide control of temperature and relative humidity within closer limits."

> To produce this effect two possibilities are open, (1) buildings upon the present plans, but thoroughly protected from cold winds, insulated against heat and cold, and furnished with efficient systems of controlling ventilation; (2) factories with their ripening rooms partly or entirely below the surface of the ground and furnished with equally good apparatus for ventilation. Both systems offer advantages. The factories at present built are successful part of the time. If better protected against changes of weather and supplied with efficient means of insuring proper moisture conditions, the same buildings may perhaps be used successfully. Without such alterations they appear to have failed as investments. If correction of their failures is possible, their use would involve the least change of methods on the part of the workmen. If the whole ripening process be put into rooms partly or entirely below ground, the exposure to storm would be reduced, the production of uniform temperatures would be much easier, and the moisture of the soil would aid in maintaining the desired humidity, but means of producing and controlling ventilation would be equally difficult to manage during a large part of the year. Such rooms if planned should if possible run into the hillside, and have opportunity for ample window space for lighting purposes. * * *
>
> Those contemplating the establishment of Camembert cheese factories should study the climatic conditions of their locality thoroughly. The Weather Bureau of the United States Department of Agriculture can furnish data as to means and extremes of temperature and relative humidity in any section of the United States. The conditions found would control the type of factory required in each locality.

The making of Camembert cheese for the general market as at present developed is feasible only on a comparatively large scale. Some work has been done to determine the possibilities of making this type of cheese on the farm, and it has been found that it is advisable only when it can be marketed directly, as is now done with cottage cheese.

CEMENT AND CONCRETE FENCE POSTS.[a]

The use of cement and concrete for farm structures of various kinds has been treated in a Farmers' Bulletin of this Department.[b] A number of the experiment stations have undertaken the study of the use of these materials for special kinds of farm structures.

A recent bulletin of the Colorado Experiment Station, by H. M. Bainer and H. B. Bonebright, reports a somewhat detailed study of the methods of making cement and concrete fence posts, and of the best forms, mixtures, reenforcements, wire fasteners, cost, and general practicability.

Cement and concrete posts are just beginning to be manufactured and used as substitutes for wood posts, but already there seems to be general agreement that such posts can readily be made on the farm with ordinary labor, and while the first cost is large the posts are long-lived and of good appearance. In the bulletin of the Colorado Station referred to a description is given of a form of homemade concrete mixer which greatly reduces the hand labor required and which is more economical and better adapted to the average farm purposes than the large patented concrete mixers. This mixer, which, it is believed, can be made by an ingenious farmer with little expense and work, is described as follows (see fig. 1):

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[a] Compiled from Colorado Sta. Bul. 148; Agr. Gaz. N. S. Wales, 20 (1909), No. 4, p. 314.

[b] U. S. Dept. Agr., Farmers' Bul. 235.

Two pieces of 4 by 6 form the sills. Upon these two uprights about 3 feet high are fastened. A 1½-inch pipe passes through holes bored in the top of the uprights. Upon this pipe the mixing box is turned, and through the pipe the water is added to the mixture at the desired time. The water is poured in at the top of the upright pipe and flows down and out through holes which are drilled in the lower side of it. The other end of the pipe is closed by a wooden plug. The ends of the box are made of pieces of 2 by 8 bolted together. A hole bored in the center of each end forms the bearings. The sides of the box are made of 1-inch lumber and are simply nailed to the ends with 12d. nails. One-half of the box is made so that it can be detached and lifted off when the mixer is to be filled or emptied. The detachable half is secured to the other half by means of strong hooks so placed that by slipping this half about an inch to one side all of the hooks are loosened at once. After it is in position the removable portion is held in place by means of a barn-door latch.

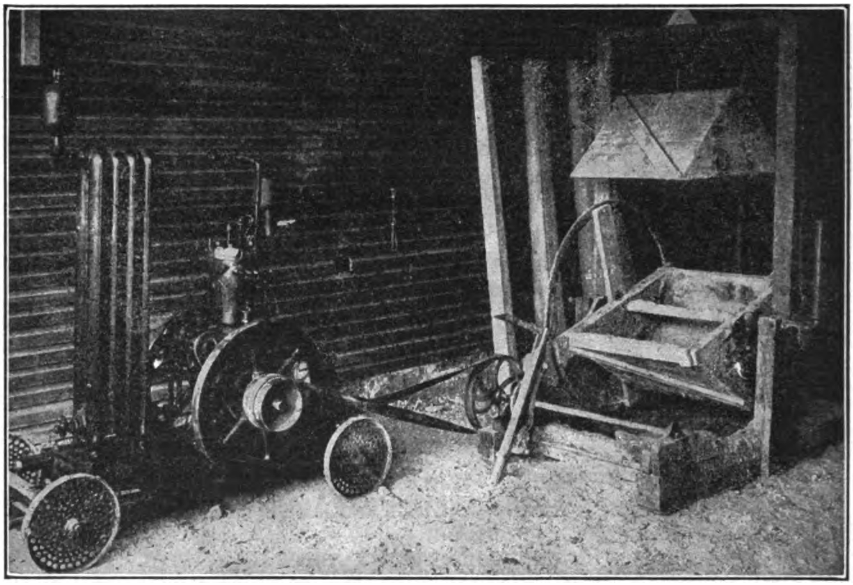

FIG. 1.—Homemade concrete mixer.

The driving gear is simple but very effective. It consists of the rim taken from the wheel of an old "rubber-tire buggy." With the tire removed the grooved rim makes a very satisfactory wheel upon which to run a three-fourths-inch rope belt. The belt is driven by a small sheave pulley which is fastened to the countershaft. A belt tightener is used upon the rope, and by using a very loose belt the tightener is made to act as a friction clutch.

This particular mixer is driven by a 2-horse gasoline engine, which is belted to the countershaft. The engine runs continuously and the mixer is started and stopped by means of the belt tightener.

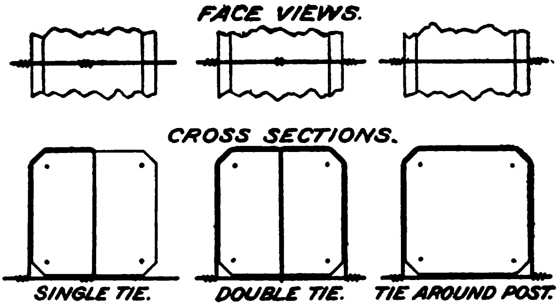

FIG. 2.—Colorado Station methods of tying wires to concrete fence posts.

The operator first fills the mixer about half full of sand, gravel, and cement in the correct proportions. He next lowers the lid, which until this time has remained supported upon the hook. The lid is now pushed into place and the latch fastened. The supporting hook is next removed from the staple in the lid and hooked into a staple in the lid support. The machine is now ready to start, the clutch is thrown in, and the box revolves upon the pipe. When three or four turns have been made, water is poured into the upright pipe until the desired amount has been added. By this time the concrete is thoroughly mixed. The clutch is loosened, the box stops revolving, the hoisting hook is hooked in the staple of the lid, the latch is loosened, and the lid raised to the top of the lid support by means of the counterweight and rope. Now, by slightly setting the clutch, the contents of the mixer are dumped into the box beneath. The operator of the machine may now refill the mixer, while the other workmen take care of the mixed material. In this way a large amount of material may be run through the machine and perfect mixing is guaranteed.

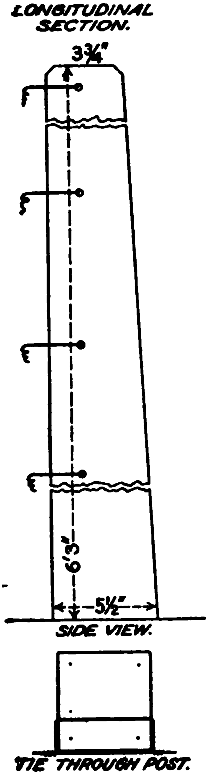

FIG. 3.—New South Wales method of tying wires to concrete fence posts.

Many other systems of driving might have been used in place of the rope belt. The main gear of an old self-binder makes an excellent gear for a mixer. An old mower gear may also be put to good use in this connection.

It is not necessary to have the mixer driven by an engine or horse power. A crank may be attached and the machine turned by hand. Many prefer turning such a machine rather than mix the concrete with a shovel.

The experiments made by the Colorado Station indicated that poured posts made from a mixture thin enough to pour from a pail or scoop almost like water are easier to make than tamped posts, but are somewhat more expensive on account of the number of molds and the time required. The poured posts were also a little over 25 per cent stronger than tamped posts of the same size, mixture, and reenforcement. They are also better able to withstand action of frost and alkali. It was found that while the commercial molds make a post which tapers from the base to the top, the most economical form of post is one which is as large at the ground line as at the base and tapers from the ground line to the top. The square or round post is equally strong in all directions, and is therefore to be preferred to the triangular post. The reenforcement should be in proportion to the size of the post and the strength of the mixture, and should be strong, light, and rough enough to permit the mixture to adhere firmly to it. It should also be very rigid, with little or no tendency to spring or stretch. Two or more wires twisted together were found to make as satisfactory a reenforcement as could be obtained. The reenforcement should be placed in each corner of the post at a depth of from three-eighths to three-fourths of an inch from the surface. Most of the commercial wire fasteners tested proved either cumbersome or expensive. A simple and satisfactory home-made fastener is shown in figure 2. The posts should be cured in the shade for at least 60 days, being sprinkled daily during the first 30 days.

In experiments with concrete posts at the Cowra experiment farm of New South Wales the wires were tied to the posts by tying wires which passed through holes in the post 2 inches from the surface. These holes are made when the posts are molded by putting one-fourth-inch rods through the sides and across the mold at the required distance apart. When the concrete sets, the rods are removed. The method of tying is illustrated in figure 3.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 385.

BOYS' AND GIRLS' AGRICULTURAL CLUBS.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., November 4, 1909.

Sir: I have the honor to transmit herewith a paper prepared under the direction of D. J. Crosby, Specialist in Agricultural Education of this Office, on Boys' and Girls' Agricultural Clubs in the United States. The interest in this form of school extension work in agriculture is so widespread, and the calls are so frequent for information concerning its history, plans, and recent development, that I recommend the publication of this manuscript as a Farmers' Bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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BOYS' AND GIRLS' AGRICULTURAL CLUBS.

INTRODUCTION.

There have been few developments in recent years of greater educational interest and significance than the work done by associations of boys and girls in agricultural and domestic-art undertakings. As a rule, these have had their beginning in some form of competitive contest for special occasions or awards. The organization of clubs has usually been an incidental outgrowth of the plans for these contests, and the name applied to the organization itself has varied widely with the different purposes carried forward. Thus we find clubs for corn growing, cotton growing, potato growing, fruit growing, poultry growing, live-stock study, bird study, home culture, and high-school improvement. All of these have been more or less agricultural in their general character.

To any who are unacquainted with the nature of such clubs it may be explained that a corn-growing club is an association of boys who enter into a competition to determine which can grow the most or the best corn on a certain area of ground under definite rules of planting, cultivation, and exhibit of their product. A cotton-growing club would undertake a similar competition in producing the best yield of cotton under prescribed conditions. For girls these contests have frequently taken the form of bread-making, sewing, or joint contests with boys in gardening or poultry raising.

The results already apparent from such competitive and cooperative work may be summarized as follows:

(1) Individually the members of such clubs have been led to observe more closely, to recognize good and bad qualities in the products they have grown, and in the insects, fungi, and other various conditions affecting their work; they have met and learned to solve some problems in the improvement of plants, fruits, animals, and housework; they have learned that improvement in one direction is not always, or even usually, accompanied by improvement in all directions; they have learned something of the value of labor, the cost of production, and the keeping of simple accounts with different farm and household affairs; they have been encouraged to read good literature and have learned some of the sources of good agricultural literature; their views have been broadened by contact with others

and by visiting institutions of learning, highly developed farms, and other places of interest; and, finally, the power of taking the initiative has in many cases been strongly developed in them as individual and responsible members of the community.

(2) Collectively they have learned the value of organized effort, of cooperation, and of compromise; and the social instinct has been developed in them—a matter of great importance in rural districts, where the isolated condition of the people has long been a great hindrance to progress.

(3) The influence upon the communities at large, the parents as well as the children, has been wholesome. Beginning with an awakening interest in one thing—better seed corn, for example—communities have rapidly extended their interest to other features of rural improvement, with the result that in the regions affected by the agricultural-club movement there has come about a general upward trend in the thoughts and activities of the people. The possibilities in corn improvement are well illustrated in figure 1.

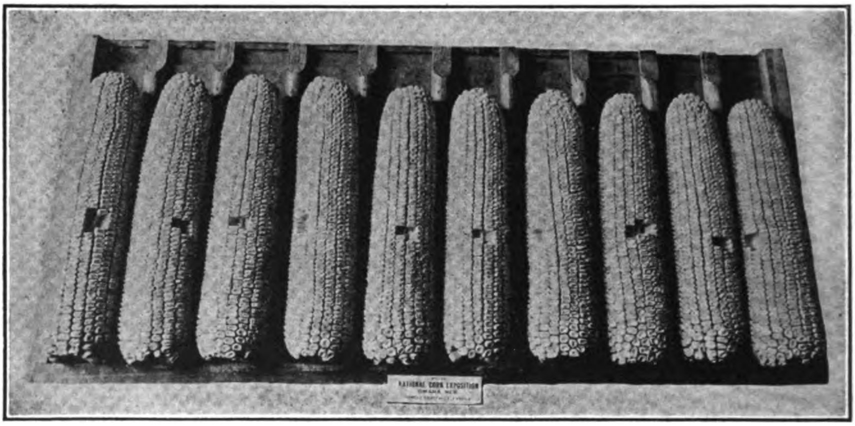

FIG. 1.—Ten best ears of corn. Exhibited by L. B. Clore, of Indiana, at the Second International Corn Exposition. These ears won the grand sweepstakes prize of $1,000.

(4) These club activities have in many instances exercised a very stimulating, if not a "redirecting," influence upon the ordinary work of rural schools and teachers.

(5) The knowledge gained from the work of these clubs has demonstrated that the natural love of competition among boys and girls (as well as their elders) can be utilized to immense advantage in furthering their own education for efficiency.

Setting aside the question whether boys' and girls' agricultural clubs may eventually be superseded by more permanent organic developments in general public education, they have at least an undoubted value at the present time and seem to be an important, if not necessary, link in the evolution toward a more efficient educational system. Experience with them has gone far enough to furnish well-tested plans for States and sections that are now ready to take up this work.

Various agencies have taken the initiative in starting this movement under particular local conditions, but the inspiration for state-wide activity in these lines has generally come from some individual or official source connected with the state department of education, the state agricultural college, or the United States Department of Agriculture. In the absence of such initiative the work has sometimes begun in the zeal and wisdom of some county officer or association, as the county superintendent of schools, the farmers' institute society, the county fair association, or teachers' association, the grange organization, or the Young Men's Christian Association. Experience has shown that the work has always been most permanent and productive when it has resulted in a definite local organization, preferably under the leadership of the county school superintendent.

HOW THE WORK HAS BEEN DONE IN CERTAIN STATES.

The best evidence of the value of this type of school extension interest may perhaps be seen in a more particular reference to the actual club work of boys and girls already successfully carried on in several States. The first state-wide movement of this kind began about 1898, in New York, under the auspices of the College of Agriculture of Cornell University, as a development from its nature-study lessons. This work has now gone over the whole State and has taken a variety of forms, such as corn-growing, potato-growing, fruit-growing, poultry-raising, and garden contests, with special prizes to girls for the best work in sewing and bread making. It has all been directed more or less closely by the Junior Naturalist Monthly, and more recently by the Cornell Rural School Leaflet, which frequently gives definite lessons in agriculture written by the college specialists. This publication reaches about 7,000 teachers and school commissioners during nine months of the year and is the official organ of the Cornell Farm Boys' and Girls' Clubs, which now have an aggregate membership of about 75,000. The prize-winning exhibits in the local school and county contests are taken to the state exhibit held each year at the College of Agriculture during "Farmers' week." At the meeting in the spring of 1909 there were nearly 450 ten-ear exhibits of corn at this "Corn show," about one-third of which came from 28 boys' and girls' clubs (fig. 2). There were also exhibited about 150 drawings on corn subjects, 150 essays on "How to grow corn," and 200 letters on "How we celebrated corn day in our school."

Nebraska is another State in which this kind of club work has been very thoroughly organized, beginning in 1905, under the leadership of the state superintendent of public instruction in cooperation with the Agricultural College of the State University, at Lincoln. Practically every county is now included in the plans. The boys grow their show corn and vegetables under directions sent out from the

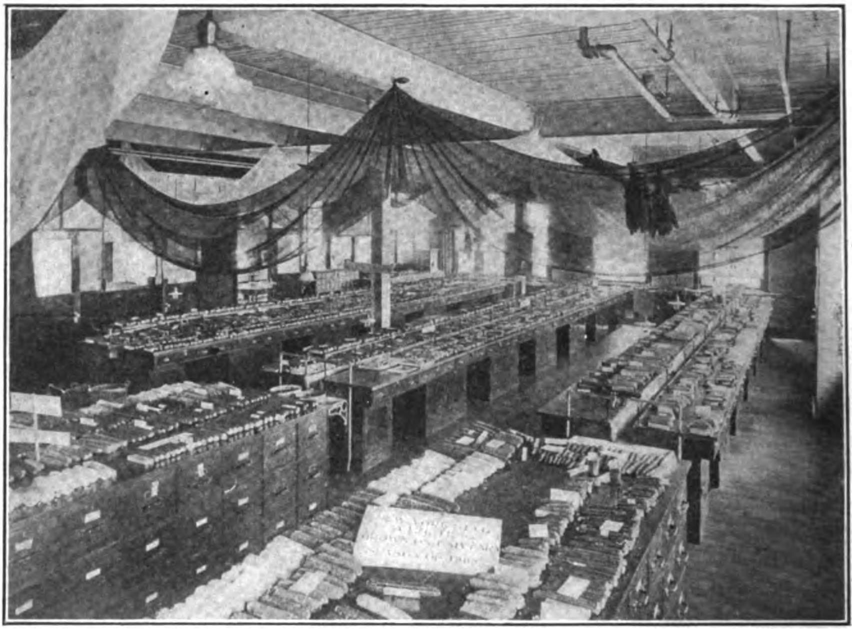

FIG. 2.—New York State Corn Show. Exhibit shown during "Farmers' week," 1909.

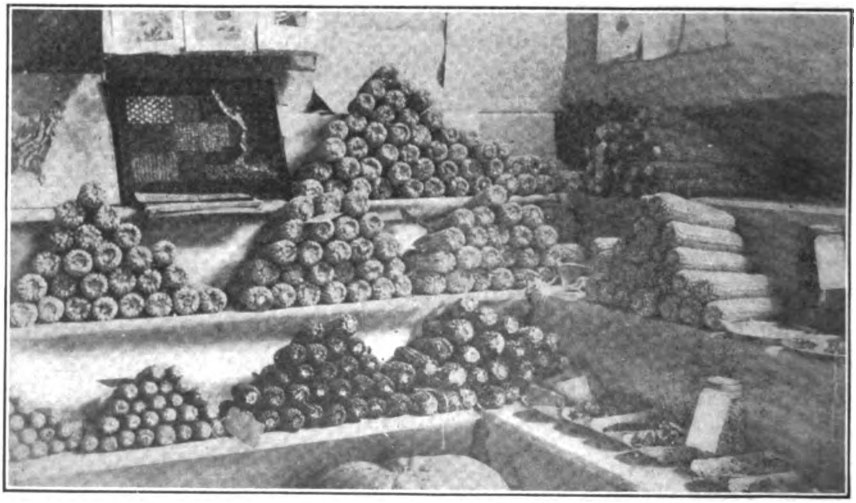

FIG. 3.—Exhibit of the Boys' Experimental Club of Nemaha County, Nebr.

state headquarters and the girls practice baking in accordance with recipes sent out to the schools from the domestic science department of the State University. Early in the fall a local contest is held in each school, the three prize-winning exhibits and the best three essays being then taken to a township show, then to a county exhibit (fig. 3), and finally to the state corn-growing and corn-cooking contest at Lincoln (fig. 4). This meeting includes a grand "corn banquet" which gathers from 2,000 to 3,000 boys and girls from over the State.

Similar work in Ohio, under the direction of the agricultural extension department of the State University, has reached practically all the rural boys and girls in the schools of the State. In Illinois this work began under the initiative of certain county superintendents of schools and in connection with the farmers' institutes. The organizing work of the Winnebago County superintendent of schools has probably had the widest publicity. Here was introduced the feature of annual excursions of the club members and their parents to neighboring experiment fields (fig. 5) and to state agricultural colleges. Club interest is also utilized in improving the school grounds and buildings of the county. One session of the county farmers' institute is set apart for the club work, and agricultural specialists from other States as well as their own have been engaged to address these sessions. Under similar county initiative this work was started in Iowa by the superintendent of Keokuk County (fig. 6), and the super-

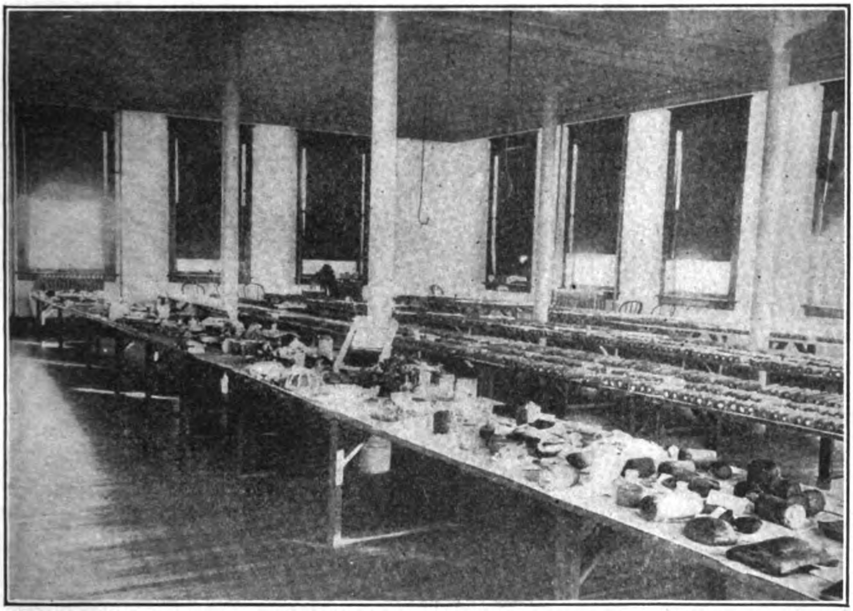

FIG. 4.—State corn-growing and corn-cooking exhibit at Lincoln, Nebr., 1905. Raw material in the background, baked products on front tables.

intendent of Page County (fig. 7). Club work for both boys and girls (fig. 8) has also been successfully established in Berks County, Pa., by the superintendent.

Among the Southern States, Texas and Georgia have been prominent in organizing this kind of work. The "Farmer Boys' and Girls' League" in the former State was organized in 1903 in connection with the Texas Farmers' Congress, and now numbers over 1,750 members (fig. 9). In Georgia this work has been directed by the State University, and the interest has been chiefly in corn and cotton growing and in the improvement of live stock. Much of the development in the Gulf and South Atlantic States has been assisted by this Department in connection with the boys' demonstration work directed by the former state superintendent of education in South Carolina.

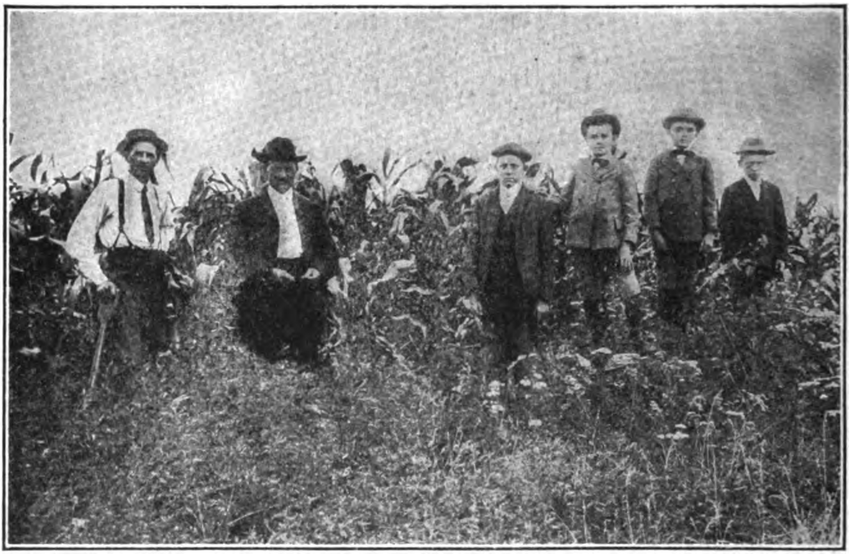

FIG. 5.—A committee of the Winnebago County (Ill.) Agricultural Club inspecting corn experiments on one of the state experiment fields.

ASSISTANCE GIVEN BY THE DEPARTMENT OF AGRICULTURE.

The Department, through the Office of Experiment Stations, has frequently given assistance in furthering the organization of this line of school extension work. It has sent out bulletins of information to those engaged in competitive contests and in some cases has secured the sending of seed from sources outside the State. Where the club work has been in operation for some time this Office, in cooperation with the Bureau of Plant Industry, has begun in an experimental way to develop the interest of members in testing some of the new fruits and vegetables introduced from other countries. In this way the Sakurajima winter radish from Japan is being grown this year by some of the Michigan boys' corn clubs.

By means of illustrated stereopticon lectures the Office of Experiment Stations has also assisted local organizers and club members in understanding what has been accomplished by junior clubs in other States and sections of this country. In 1904 it issued a Yearbook reprint on "Boys' Agricultural Clubs," which gave a survey of the agricultural club movement so far as it had then developed.

The purpose of the present bulletin is to give further information and suggestion to state and county superintendents and rural teachers who desire to keep abreast with the advancing development of this interesting and valuable form of school work. Such school-extension work furnishes an effective means of reaching, holding, and directing the interest and energies of boys and girls who are without as well as within the schools, and so promotes the betterment of the social, educational, and economic conditions affecting country life.

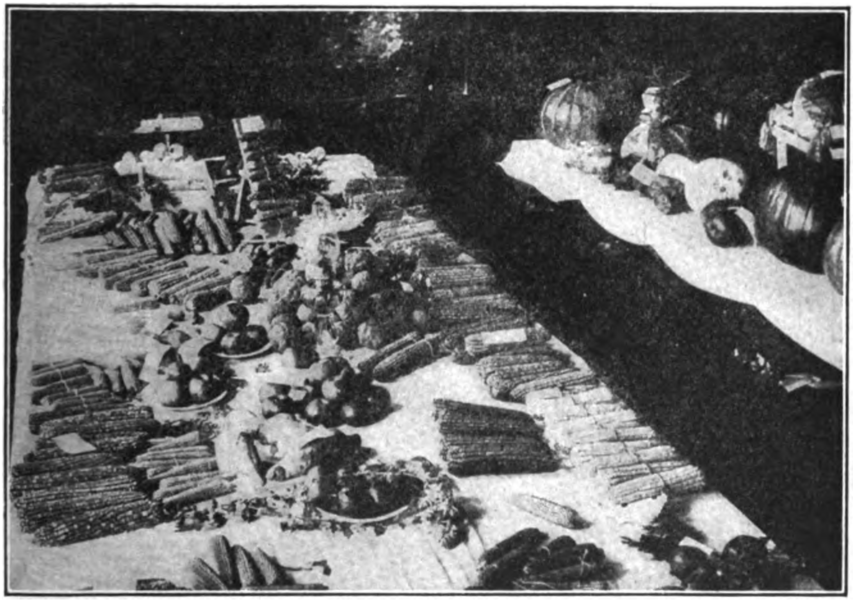

FIG. 6.—A Keokuk County (Iowa) school exhibit.

THE RELATION OF CLUB WORK TO RURAL EDUCATION.

The organization and work of these various clubs has in many cases assumed the character of school "extension work" in agricultural education. As such it is directly contributory to the field of agricultural education in general; but in many instances it has acquired a very intimate relation to the regular work of the public elementary and secondary schools. Thus in Ohio the state superintendent of agricultural extension work writes that most of the boys' and girls' club activities are now conducted as a part of the school work and that "agricultural clubs as such are coming to be things of the past," so that no separate records or statistics of such work are now generally kept in that State.

FIG. 7.—A Page County (Iowa) club worker.

The exhibits of what has been accomplished by these clubs are frequently the most attractive features of local and state fairs, and have perhaps done more than any other single influence to inspire the interest of the people in the usefulness of the instruction given in the common schools. The influence of such work upon the developing ideals of the proper function of the schools and their relation to the coming type of country-life education is well shown in the prizes offered in a recent western state fair:

> These prizes range from $2 to $25 for exhibits of work teaching girls household service and home appreciation; of work in applied civics and school service to the community; evidence of cooperative neighborhood work for school building and ground improvement; children's garden work, with plans, photographs, and descriptions; arithmetic applied to industrial and business affairs of the school, home, and community; "field work" in geography; class record of weather observations for three months or more; plan of farm (drawn, modeled, or constructed), showing buildings, irrigation system, crop rotation, etc.; construction work done by any pupil, showing mechanical and inventive ability, and best single exhibit of courses of study, plans, etc., showing ways of making school instruction more valuable and connecting it more intimately and vitally with community life.

SUGGESTIONS FOR THE ORGANIZATION AND WORK OF JUNIOR AGRICULTURAL CLUBS.

There are obvious advantages in merging agricultural club work closely with the interests of the public school and the home life of the pupils. The county superintendent of schools is in a position to utilize such community interest to the greatest benefit in vitalizing and unifying the enthusiasm of teacher, pupil, and parent. He can explain the plans of work to his teachers, and they in turn to pupils and parents, thus securing the clear understanding and cordial cooperation of all concerned.

FIG. 8.—Berks County (Pa.) Domestic Science Club, showing button badges bearing the motto: "Better Housekeeping." (Prizes awarded at county teachers' meeting.)

There is need of a concrete object of effort in all such associated activity, and the local corn-growing, bread-making, or fruit-raising contest furnishes such an object. This object should be varied from year to year, or at least new lines of effort should be joined to it, in order to maintain a live and growing interest. The organization under which the work is done should be simple but definite. Responsibilities should be real and clearly placed. Orderliness is essential to impartiality and harmony. But the anatomy of the organization should be not conspicuous; the "average boy" does not derive much enjoyment from riding a horse of pronounced gothic structure, even in the cornfield.

The year's experiment or contest should be planned carefully, definitely, and early. Appropriate prizes and trophies should be provided. Reports of contestants should be received at intervals during the season, on blanks or suggestions previously given out. Letters of direction and encouragement should be sent at critical times from the local headquarters. Circulars, bulletins, and other means of instruction are to be supplied, and should always include the publications of the state agricultural college, the state experiment station, and the United States Department of Agriculture, in reference to the subject in hand. One of the chief values in this work is the training it gives in finding and using information that has already been published. State-wide cooperation with other clubs and with the agricultural college and experiment station should be secured, and if possible with the state superintendent of public instruction and the state fair association.

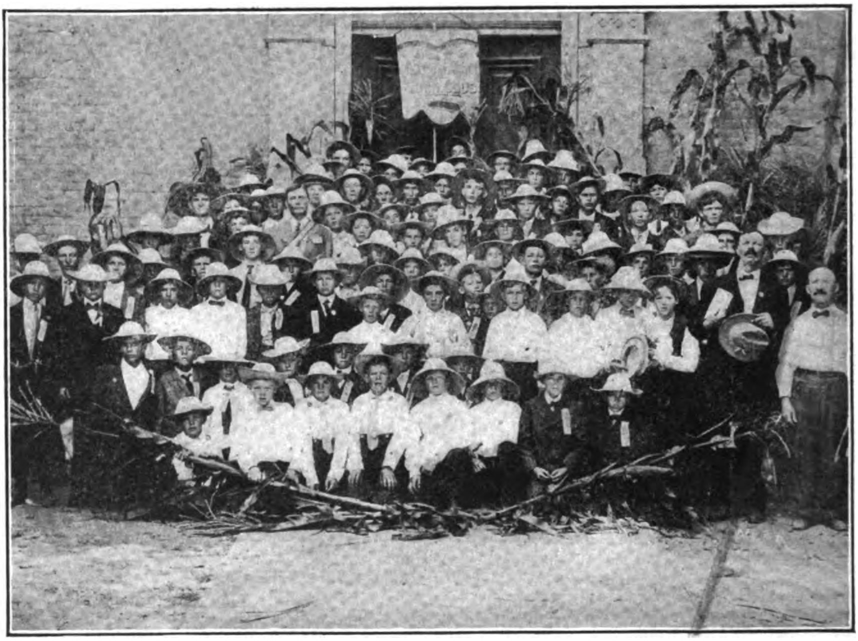

FIG. 9.—Grayson County (Tex.) Corn Club, showing uniform hats and badges.

Occasional lectures and demonstrations should be made at county meetings of members, which may sometimes be held with advantage in connection with the county teachers' and farmers' institutes (see fig. 8, p. 13). As early as practicable the organization should develop plans for an annual district school exhibit of competing agricultural and domestic-art products, followed by township, county, and state exhibits, the latter in connection with the state fair or the meeting of the state teachers' association. A distinctive badge or button (see figs. 8 and 9, pp. 13 and 14) worn by the boy and girl members of the clubs adds much to the feeling of community interest and dignity.

THE FIRST MEETING.

The first meeting for organization should include as many boys and girls of the county as can be brought together in the most convenient place. This meeting should be called by the county superintendent (or commissioner) of schools and should be thoroughly advertised in the county schools and papers. If possible it should be held while the schools are still in session, before the spring vacation; and it should announce a definite object. The following is suggested:

NOTICE.

The boys and girls in the schools of ——— County, and any others between the ages of 12 and 18 years who wish to join them, are cordially invited to meet in the high school building in ———, on Saturday, ———, 19—, at — o'clock.

The object of this meeting is to organize for the purpose of engaging in a county corn-growing and bread-baking contest this year. Each contestant will be supplied with seed, if necessary, and with complete directions for doing the work. An illustrated talk will be given by ———. Some fine prizes for the best work, amounting to $———, have been offered by ——— ———. If you want to get acquainted with other boys and girls in the county and enter into a lively and happy competition with them for these prizes, don't fail to be present at the time appointed. Bring your teacher with you and as many parents as wish to come. If you come by rail, buy a "party ticket" so as to get the best rate. *Don't come too late.*

Yours, for better corn and bread,

——— ———,

County Superintendent of Schools.

The prizes offered in such contests can usually be arranged for by cooperation with the county grange, farmers' institute society, teachers' association, bankers, leading merchants, and various local associations. The prizes may take the form of money, trophy cups, or banners, cultivating tools or planters, bread-making sets, bicycles, suits of clothes, "due bills" for merchandise, etc.

Near the close of the meeting, which should not be too long, a simple form of constitution should be ratified. It should have been previously agreed upon by the members of the "advisory committee." Usually it will require no discussion and can be adopted by a rising vote. If time is limited the regular officers of the club may be elected at a later meeting; but there is decided advantage in placing responsibility of this kind upon the boys and girls themselves and developing familiarity with good parliamentary practice. The following general form of organization has been found satisfactory.

CONSTITUTION.

ARTICLE I. Name of club.

ARTICLE II. Objects of club.

ARTICLE III. Membership (including badge or button, and a provision for honorary members, if desired).

ARTICLE IV. Officers. (A president, one vice-president from each school district, a secretary-treasurer, and an advisory committee consisting of the county superintendent, the lecturer of the county grange, and the president of the county farmers' club or institute society.)

ARTICLE V. Duties of members. (As prescribed in the rules for contests.)

ARTICLE VI. Duties of officers. (Defined as usual in such organizations.)

Section —. The advisory committee shall arrange for all public contests and exhibits, the procuring and awarding of prizes, the sending of letters and circulars of information, the general county meetings of the club, and the reporting of statistics and other information to the state organizer.

ARTICLE VII. Subsidiary clubs.

Each local school having —— club members within its district may organize as a local club with its own officers, badge, local prizes, etc. Its advisory committee shall consist of the district school board and teachers, and its president shall be one of the vice-presidents of the county club.

When the constitution has been adopted membership should be determined by the collection of signed blanks, previously distributed, showing data as given in the following form:

ENROLLMENT RECORD.

Date ———, 19—.

I wish to join the ——— County ——— Club, and hereby promise to follow all the rules of membership and contests.

(Signed) ——— ———.

Age at nearest birthday —. Date of birth ———, 19—.
Township ———.
School district ———.
Teacher ——— ———.
My post-office address ———. Box number ——. R. F. D. No. ——.

The members of a corn-growing club usually keep a careful record of all work done in connection with the annual contest. It is advantageous to supply the basis for this in the form of a little memorandum book which covers the following items and may well include the club constitution and list of officers:

HOW THE CROP WAS GROWN.

1. Grown by ———, school district ———.
2. Post-office address ———.
3. Area of plat in square rods ———. (Not less than — acre.)
4. Kind of soil (loam, sand, clay) ———.
5. Kind of crop grown on it the year before ———.
6. Kind of crop grown on it the second year before ———.
7. Kind and amount of fertilizer used ———.
8. Cost or value of fertilizer ———.
9. Date of plowing ———. Hours required, self ——, horse ——.[a]

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[a] If two horses are used, count as twice the time of one horse.

10. Depth of plowing (in inches) ———.
11. Additional preparation of the ground:
    (a) How many times disked ——, when ———.
    (b) How many times harrowed ——, when ———.

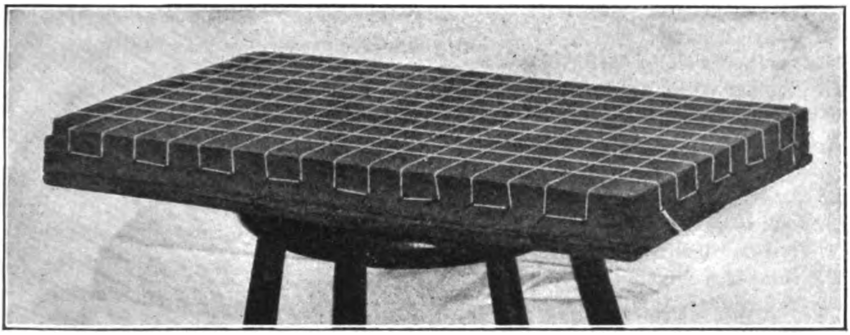

FIG. 10.—Sand-tray seed-corn germinator, ready for planting. Five or six kernels from one ear planted in each square marked off by the string laced over the tray. The tray is sawed from a soap box and filled with sand.

    (c) How otherwise prepared ———.
    (d) Total hours work of preparation, self ———, horse ———.[a]
12. Kind of corn planted ———. Variety name ———.
13. Seed procured from ———.

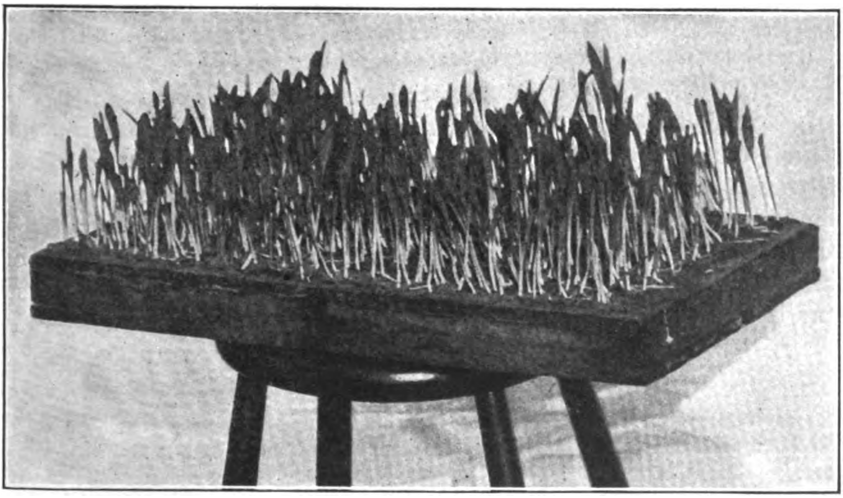

FIG. 11.—Sand-tray seed-corn germinator, with plants about ten days old. Test developed far enough to determine ears fit for seed.

14. Quantity of shelled corn used for seed ———.
15. Number of ears tested ———. Number of kernels from each ———.
16. Method of testing[b] ———.

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[a] If two horses are used, count as twice the time of one horse.

[b] Note figures 10 and 11.

17. Number of ears which proved satisfactory ———.
18. Number of hills planted ———; date ———, 19—.
19. Date when first hills came up ———.
20. Number of hills failing to come up ———; why ———.
21. Date of each cultivation and implement used ———.
22. Total hours cultivation; self ——, horse ——.[a]
23. Date of hoeing crop ———, 19—. Hours work ———.
24. Number of stalks with two ears ———.
25. Number with no ears ———.
26. Number of hills with three stalks ———; two ———; one ———.
27. Date of first tassels appearing ———, 19—; ears ———, 19—.
28. Date of any frosts on the crop ———, 19—.
29. Date of cutting and shocking ———, 19—.
30. Date of husking ———, 19—.
31. Date of selecting ears for exhibit ———, 19—.
32. Number of ears first selected ———; weight in pounds ———.
33. Care of selected ears after husking ———.
34. Weight of ten ears at time of exhibit ———.
35. Was the selecting done without any other person present? ———.
36. Was all the work of production done by the contestant (except plowing, weighing, and hauling the crop)? [b]———.
37. Total number of hours worked ———.
38. Total number of hours horse[a] worked ———.
39. Value of own work at ———[c] cents per hour, $———.
40. Value of horse's[a] work at ———[c] cents per hour, $———.
41. Value of ground rent for crop at ———[c] per acre, $———.
42. Value of fertilizers used, $———.
43. Value of salable crop at ———[c] cents per bushel, $———. (Weigh good ears when drawn from field, and count 70 pounds to the bushel.)
44. Profit on the season's work, $———.

In addition to the foregoing record, which should accompany the exhibit offered by the contestant, an essay covering the same facts in a connected description is often required. This and the calculations required in the report furnish a helpful means of connecting field work with school work. It is usual to announce at the time of the first meeting the special rules that govern the contests. These may be conveniently summarized in the following form:

RULES FOR CONTESTANTS.

1. Each contestant is allowed to make only one exhibit entry each year.

2. Each contestant must be regularly enrolled in the county club before beginning work.

3. Each contestant must be under ——— years of age.

4. Each contestant for corn prizes must prepare his ground, test seed, plant, cultivate, cut, and husk crop, all without assistance from any other person. (He may have assistance in plowing, fertilizing, and hauling crop, and should have in weighing it.)

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[a] If two horses are used, count as twice the time of one horse.

[b] Draw line through "plowing" and "hauling" if contestant did that alone.

[c] Should be uniform rate agreed upon for the whole State.

5. Each contestant must study the score card and the bulletins recommended by the state organizer.
6. Each contestant on essays shall write not more than ——— words, and all must carefully fill the blanks on "How the crop was grown."
7. Each contestant's record and essay must be indorsed, with his exhibit, by his district teacher as evidence of her confidence that it is all the product of his own work.
8. All exhibits are to be the property of ——— ———[a] at the end of the exhibit.

Corn growing and bread making or sewing are the most convenient objects of effort in starting this kind of work. Rules for the girls' contests should be obtained from the domestic art department of the agricultural college or other state institution admitting girls. Other forms of contest may be started the second year if desired.

AVAILABLE PUBLICATIONS.

Most of the bulletins and circulars included in the following lists, with the exception of the Farmers' Bulletins, were prepared more or less directly with reference to junior club work and study. A few others have been given because of their general relation to some phase of the work described in the foregoing pages. In many cases these will suggest new lines of club work that may be entered upon at a later time. The list could easily be made much longer, but care has been taken to include no publication for which a price is charged.

In sending for copies of these publications care should be used to designate exactly by title, number, and volume or series. None of these is supplied by the Department of Agriculture except the Farmers' Bulletins and others specially designated as publications of the Office of Experiment Stations. As a rule, bulletins issued by some State other than that in which the applicant resides can not be had in quantity, but may often be had in numbers sufficient to supply the members of the advisory committee mentioned on page 16.

GENERAL, ON CORN.

The Nebraska Corn Book, Department of Public Instruction, Lincoln, Nebr.
Studies of Corn and Its Uses, Illinois Agricultural College Extension Bulletin, Urbana, Ill.
Corn Study, South Dakota Agricultural College Bulletin, Vol. II, No. 2.
Corn Growing, Farmers' Bulletin 199, U. S. Department of Agriculture.
The Production of Good Seed Corn, Farmers' Bulletin 229, U. S. Department of Agriculture.
Corn Culture in the South, Farmers' Bulletin 81, U. S. Department of Agriculture.
Food Value of Corn and Corn Products, Farmers' Bulletin 298, U. S. Department of Agriculture.

SEED-CORN SELECTION.

Bulletin 116, Agricultural Experiment Station, Kingston, R. I.
Bulletin 122, Agricultural Experiment Station, Lexington, Ky.

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[a] They are sometimes sold at auction when the expenses of the meeting are not otherwise met.

Agricultural College Extension Bulletin 1, Vol. II, Columbus, Ohio.
Agricultural and Mechanical College Bulletin 2, Teachers' Series, Stillwater, Okla.
Farmers' Bulletins 229 and 253, U. S. Department of Agriculture.

SEED-CORN TESTING.

Special Bulletin 47, Agricultural Experiment Station, East Lansing, Mich. (See figures 10 and 11 for illustrations—taken from this bulletin—of a simple sand-tray method of testing seed corn.)
Agricultural College Extension Bulletin 7, Vol. II, Columbus, Ohio.
Agricultural and Mechanical College Bulletin 2, Teachers' Series, Stillwater, Okla.
Farmers' Bulletins 229 and 253, U. S. Department of Agriculture.

TIME AND METHODS OF PLANTING.

Bulletins 55, 65, Agricultural Experiment Station, Experiment, Ga.
Bulletin 147, Agricultural Experiment Station, Manhattan, Kans.
Bulletin 104, Agricultural Experiment Station, Clemson College, S. C.
Bulletin 134, Agricultural Experiment Station, Auburn, Ala.
See also the general bulletins in first list.

FERTILIZERS AND HOW TO APPLY THEM.

Farmers' Bulletins 44, 192, U. S. Department of Agriculture.

CULTIVATION.

See first list.

CORN HARVESTING METHODS AND MACHINERY.

Farmers' Bulletins 303, 313, U. S. Department of Agriculture.

CORN PLAT MEMORANDUM BOOK.

G. I. Christie, Lafayette, Ind.[a]

CORN JUDGING.

See first list and state score card.

USES OF CORN FOR LIVE STOCK.

Bulletin 102, Agricultural Experiment Station, Urbana, Ill.
Farmers' Bulletins 22 and 32, U. S. Department of Agriculture.

USES OF CORN FOR FOOD.

Farmers' Bulletins 249, 298, U. S. Department of Agriculture.

BREAD-MAKING CONTESTS AND RECIPES.

Nebraska Corn Book, Department of Public Instruction, Lincoln, Nebr.
Agricultural College Extension Bulletin 10, Vol. IV, Columbus, Ohio.
Farmers' Bulletin 112, U. S. Department of Agriculture.

MILK AND BUTTER TESTS AT HOME.

Farmers' Bulletins 63, 131, 241, U. S. Department of Agriculture.
Agricultural College Extension Bulletin 4, Vol. I, Columbus, Ohio.
Agricultural College Extension Dairy Lessons, 1, 2, 3, 4, etc., University of Illinois, Urbana, Ill.
Testing Milk on the Farm (Form 10), University of Illinois, Urbana, Ill.

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[a] Not the printer, but the designer of this memorandum book, which contains most of the items in the record shown on pages 16–18. A sample copy can probably be obtained by sending postage to him.

COTTON GROWING AND JUDGING.

Bulletins 6, 98, University of Georgia, Athens, Ga.
Farmers' Bulletins 217, 285, and 302, U. S. Department of Agriculture.

POTATO GROWING.

Farmers' Bulletin 35, U. S. Department of Agriculture.

STRAWBERRIES.

Farmers' Bulletin 198, U. S. Department of Agriculture.

JUDGING CATTLE.

Agricultural College Extension Bulletin 9, Vol. II, and Bulletin 2, Vol. V, Columbus, Ohio (and official score card and rules).

JUDGING HOGS.

Bulletin 98, University of Georgia, Athens, Ga.

POULTRY RAISING.

Agricultural College Extension Bulletins 1, 2, 3, etc., Corvallis, Oreg.
Bulletin 98, University of Georgia, Athens, Ga.
Farmers' Bulletins 64, 200, 287, 355, and 357, U. S. Department of Agriculture.

STUDY OF USEFUL BIRDS.

Agricultural College Extension Bulletin 10, Vol. IV, Columbus, Ohio.
Farmers' Bulletin 54, U. S. Department of Agriculture.

STUDY OF WEEDS.

Agricultural College Extension Bulletin 1, Vol. V, Columbus, Ohio.
Farmers' Bulletins 28, and 188, U. S. Department of Agriculture.

RURAL SCHOOL IMPROVEMENT.

Circular of Information No. 6, Bureau of Education, Washington, D. C.
Some Problems of the Rural Common School, Yearbook reprint 1905, U. S. Department of Agriculture.

AGRICULTURE IN RURAL SCHOOLS.

Agriculture Leaflets, Department of Public Instruction, Lincoln, Nebr.
Bulletin 22, Series 7, University of Ohio, Columbus, Ohio.
Bulletin 1, University of Minnesota, Minneapolis, Minn.
Bulletin 1, vol. 7, Oklahoma Agricultural and Mechanical College, Stillwater, Okla.
The Teaching of Agriculture in the Rural Common Schools, Circular 60, Office of Experiment Stations, Washington, D. C.
Secondary Education in Agriculture in the United States, Circular 91, Office of Experiment Stations, Washington, D. C.

SCHOOL GROUND IMPROVEMENT.

Tree Planting, Farmers' Bulletin 134, U. S. Department of Agriculture.
Annual Flowering Plants, Farmers' Bulletin 195, U. S. Department of Agriculture.
The School Garden, Farmers' Bulletin 218, U. S. Department of Agriculture.

IMPROVING FARM BUILDINGS AND GROUNDS.

Practical Suggestions for Farm Buildings, Farmers' Bulletin 126, U. S. Department of Agriculture.
Modern Conveniences for the Farm Home, Farmers' Bulletin 270, U. S. Department of Agriculture.

Beautifying the Home Grounds, Farmers' Bulletin 185, U. S. Department of Agriculture.

The Home Fruit Garden, Farmers' Bulletin 154, U. S. Department of Agriculture.

The Home Vegetable Garden, Farmers' Bulletin 255, U. S. Department of Agriculture.

THE STUDY, HANDLING, AND REPAIR OF FARM MACHINERY.

How to Run Farm Machinery (Form 15), Easy Illustrated Lessons in the Care and Repair of Plows, Mowers, Binders, and Gasoline Engines; How to Mix and Use Concrete, Lay Tile, and Splice Ropes; University of Illinois, Urbana, Ill.

The Repair of Farm Equipment, Farmers' Bulletin 347, U. S. Department of Agriculture.

PLANS FOR JUNIOR AGRICULTURAL CLUBS.

Ohio University Bulletin 10, Series 8, Columbus, Ohio.

Ohio University Bulletin 22, Series 7, Columbus, Ohio.

The Winnebagoes, 1903, County Superintendent O. J. Kern, Rockford, Ill.

The Country School and the Country Child, County Superintendent O. J. Kern, Rockford, Ill.

Nebraska Boys' and Girls' Associations, University Bulletin, Lincoln, Nebr.

The Nebraska Corn Book, Department of Public Instruction, Lincoln, Nebr.

Boys' Agricultural Club Bulletin, County Superintendent Jessie Field, Clarinda, Iowa.

Bulletin 98, University of Georgia, Athens, Ga.

Mississippi School Boys' Experiment Club, Agricultural College, Miss.

Bulletin 1, Vol. 7, Agricultural and Mechanical College, Stillwater, Okla.

The Grout Farm Encampment, University of Illinois, Urbana, Ill.

Vocational Possibilities in Country Schools, County Superintendent E. M. Rapp, Reading, Pa.

Developing the American Farm Boy, University of Illinois, Urbana, Ill.

Statistics of junior agricultural clubs thus far reported.

State.	No. of counties.	Counties organized.	Approximate membership.	Under the auspices of—	Objects.
Alabama	67	6	390	Commissioner of Agriculture, Agricultural College, U. S. Department of Agriculture.	Corn.
Arkansas	77	50	3,000	Superintendent of public instruction, Agricultural College, U. S. Department of Agriculture.	Corn.
Delaware	3	1	([a])	State Corn Growers' Association.	Corn.
Florida	45	1	20	Mrs. Kirk Monroe	Birds.
Georgia	137	9	[b] 350	Agricultural College, U. S. Department of Agriculture.	Corn, cotton, live stock.
Illinois	102	2	[b] 1,100	County superintendents, College of Agriculture.	Corn, bread making.
Indiana	92	45	[b] 5,000	Superintendents of agricultural extension and farmers' institutes.	Corn, wheat, potatoes, bread, sewing.
Iowa	98	([a])	4,400	County superintendents, Agricultural College.	Corn, potatoes, flowers, sewing, cooking.
Kentucky	119	10	([a])	Commissioner of Agriculture	Corn.
Louisiana	59	14	1,140	Superintendent of Agricultural Schools, U. S. Department of Agriculture.	Corn.
Maine	16	([a])	[c] 600	College of Agriculture, state superintendent of public instruction.	Gardening, school improvement.
Massachusetts	14	([a])	630	Agricultural College, North Adams State Normal School.	Corn, potatoes, gardening.

[a] Not reported.

[b] Many others compete who are not club members.

[c] The membership of the "School Improvement League" includes all public schools.

Statistics of junior agricultural clubs thus far reported—Continued.

State.	No. of counties.	Counties organized.	Approximate membership.	Under the auspices of—	Objects.
Michigan	83	6	1,500	Michigan Corn Growers' Association, U. S. Department of Agriculture.	Corn.
Minnesota	84	28	([a] [b])	College of Agriculture, Department of Public Instruction.	Corn.
Mississippi	76	30	6,000	Commissioner of Agriculture, U. S. Department of Agriculture.	Corn, cotton, home culture.
Nebraska	91	59	25,000	College of Agriculture, superintendent of public instruction.	Corn, sewing, cooking.
New York	61	([a])	75,000	State College of Agriculture	Corn, potatoes, fruit, poultry, domestic art.
North Carolina	95	9	350	U. S. Department of Agriculture.	Corn.
North Dakota	45	20	5,000	State Agricultural College	Corn, potatoes, strawberries.
Ohio	88	([a])	5,000	Extension department, State University.	Corn, domestic art.
Oklahoma	75	40	2,030	State Agricultural College, U. S. Department of Agriculture.	Corn, cotton, wheat domestic art.
Oregon	33	([a])	100	State Agricultural College	Poultry.
Pennsylvania	67	1	2,000	County Superintendent E. M. Rapp.	Corn, bread making.
South Carolina	41	7	300	Commissioner of Agriculture, state superintendent of education, U. S. Department of Agriculture.	Corn.
Tennessee	96	4	800	Public school teachers	Corn experiments, school improvement.
Texas	232	41	[b] 1,760	Texas Farmers' Congress, U. S. Department of Agriculture.	Corn.
Virginia	100	11	2,500	State superintendent, U. S. Department of Agriculture.	Corn, domestic art.
Washington	36	1	200	State Agricultural College	Wheat, potatoes, school grounds.
Total	2,132	395	144,170		

[a] Not reported.
[b] Many others compete who are not club members.

The foregoing statistics of the junior agricultural club movement were secured by correspondence with agricultural college men who have been instrumental in forwarding the movement, with state superintendents of public instruction, and with county superintendents of schools and others. While the figures show that a large number of boys and girls are organized into such clubs, it is almost certain that the number is much larger than is shown in the table. This conclusion is drawn from the fact that in some States where such work has been carried on for several years practically no figures indicating the extent of the movement could be secured. The table is therefore intended more as an indication of the nature and scope of the movement than as a complete record of its status at the present time.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued January 10, 1910.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 386.

POTATO CULTURE ON IRRIGATED FARMS OF THE WEST.

BY

E. H. GRUBB,
Carbondale, Colo.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., December 30, 1909.

SIR: I have the honor to transmit herewith a paper on Potato Culture on Irrigated Farms of the West, prepared by Mr. E. H. Grubb, a practical potato grower of Colorado, who has been very successful in the commercial production of potatoes as well as in developing superior strains of varieties peculiarly suited to the irrigated area in which he is located. The methods described are largely based on the writer's experience.

Respectfully,
A. F. WOODS,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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POTATO CULTURE ON IRRIGATED FARMS OF THE WEST.

INTRODUCTION.

The natural home of the potato is the mountain valleys of South America. Where natural conditions are favorable for the growth of a plant, there it will reach the highest degree of perfection. In the mountain valleys of Colorado are found conditions of altitude, soil, and moisture naturally favorable to the growth of the potato, with an almost entire absence of harmful freezes and bacterial enemies.

PREPARATION OF THE SOIL.

In providing a suitable soil for potatoes, the question naturally arises, How shall we perfect and husband fertility? Live stock is the real basis of success in every agricultural district of the world. The feeding of grains and grasses on the farm replaces in the soil the vegetable matter which produces the humus and furnishes the nitrogen that keeps up the fertility of the soil. In the mountain country, where water is a prime requisite, it should be remembered that there is no better storage for water in the soil than decayed vegetable matter, and if one grows grain crops and ships them off every year, his land will become less porous and harder to work, and fungous diseases will more readily find a lodgment there. It is utterly impossible to grow good potatoes without an open porous soil.

Nothing but the legumes—alfalfa or clover—should be used as a foundation crop. The writer grows clover or alfalfa, one or the other (sometimes both), for three or four years previous to a potato crop. The soil is broken up in the fall quite deep. The winter freezes disintegrate the soil and loosen it from the roots, thus putting it in fine mechanical condition for the seed bed. Fall plowing is beneficial for the additional reason that it puts the soil in better condition to receive and store heat from the rays of the sun than spring plowing. In the spring the fall plowing should be worked over with a disk or a spring-tooth harrow until it is thoroughly fined. The seed bed should be put in as good tilth as a garden, by repeated harrowings. It is very important that the soil be well fined and well firmed in order that the root system of the young plant may be able to secure plant food as quickly as possible.

PLANTING.

USE OF PLANTING MACHINES.

Planting potatoes by hand on any large scale is out of the question on account of the expense. The large potato grower can of course afford the most modern machinery. In a community of small potato growers it is possible for them to own machinery jointly, and thus avoid any large expense to the individual farmer. The two most expensive machines connected with potato growing are the planter and the digger. (See fig. 1.) A planter will cover 5 or 6 acres a day, so that during the planting season, in the irrigated regions of the West, one planter will cover 100 acres. A good planter will cost about $70 in the West, and this expense divided among 10 farmers growing 10 acres each is a trifle.

A word of caution about the type of planter is perhaps desirable. There are some planters which pick up the seed potatoes by means of a prong or fork which breaks the skin of the tuber. This exposes the potato to any germs of potato diseases which may be present in the soil. Furthermore, it carries any germ disease that may be on some of the seed potatoes to others. There are planters which pick up the potatoes in such a way as not to break the skin. This point is especially important in planting whole seed. In planting cut seed there is still the danger of transferring the disease from one piece of potato to another. Whatever planter may be used, some one should ride on the machine in order to see that it works regularly, so as to give as nearly a perfect stand as possible.

FIG. 1.—Potato digging on an irrigated farm near Carbondale, Colo.

The improved planters of to-day open the furrow, drop the seed, cover it, firm the dirt over the seed, and mark the next furrow. Such a planter is drawn by two horses. The writer plants the potatoes about 2 or 2½ inches below the surface of the soil. Experiments with potatoes planted in rows all the way from 36 to 42 inches apart indicate that the best distance depends upon the seasonal conditions and type of soil; it is a problem for each grower to solve for himself. The distance apart the potatoes should be planted in the row also depends so much upon the variety, the fertility of the soil, the availability of water, etc., that each farmer must determine this from his own experience. I plant them 8 inches apart in rows 36 inches apart. This gives the largest tonnage of potatoes of desirable size.

CUTTING SEED; PLANTING WHOLE TUBERS.

The writer's experience has been that seed of large size (2 to 6 ounces) produce strong vigorous shoots, as they furnish an ample supply of plant food to sustain a strong and vigorous growth until the feeder roots can take up the food from the soil. An insufficient supply of plant food in the seed may cause the plant to become stunted before the root system becomes so developed that it can take up the plant food from the soil.

During the last two years the best results were obtained from planting medium-sized whole seed. While the cost of the seed has been considerably greater, the stand has been approximately perfect. Experience has proven that from one or two eyes only are sprouts developed in uncut seed. The seed end furnishes a strong vine; the other eyes usually remain dormant.

One of the greatest advantages of using whole seed is the protection from disease which may be present in the soil and which may attack the more tender exposed parts of the cut seed. The potato grower can ill afford to grow a crop of potatoes and lose from 20 to 40 per cent of a stand on account of using poor seed, or improperly cut seed, or seed of weak vitality. It is a matter of vital importance to get the plants started into strong, vigorous growth in order that they may better withstand adverse conditions later in the season.

CULTIVATION.

As soon as possible after the potatoes are planted the cultivator should be started. This implement has four shovels, each 4 or 5 inches wide and about 15 inches long, two on each side of the row, and is drawn by two heavy horses. These shovels should run as close as possible to the planted tubers without disturbing them. The first cultivation adds to the depth of the dirt over the seed, and permits the use of a light smoothing harrow without disturbing the tubers. The cultivator also loosens the soil on each side of the row and better fits it for the potato roots which will soon invade it.

After this the potatoes should be harrowed once a week, if possible, first lengthwise of the rows and then across, until the vines are 5 to 6 inches high. This practice gets rid of the weeds so thoroughly that the use of the hand hoe in the row is rendered unnecessary. It destroys all the weeds in the hills and between the hills in the row.

After this the cultivator is used but is not run so deep as at the first cultivation. Frequent shallow cultivation keeps the surface of the soil loose, conserves the moisture, and gives a chance for the root system to spread.

IRRIGATION.

With thorough cultivation, for potatoes planted the first of May, irrigation is seldom necessary until July. Generally speaking, irrigation water is cold and it is highly important not to irrigate too frequently, since the water not only causes the soil to run together but lowers the temperature to a point that is not favorable to the growth of potatoes. Irrigation water is applied only when the condition of the plants indicates that they are in need of water, as by darkening of the foliage. Or one may dig down in the hill and press a handful of soil in the hand; if it fails to retain its form, irrigation is needed. Care should be taken not to wait until the ground is too dry, because one can not cover the whole field of potatoes in one day's irrigation, and some are likely to suffer for water before being reached. The writer's experience is that if potatoes are grown as rapidly as possible, so as to become strong and well established early in the season, they withstand the maximum of unfavorable weather conditions later on, when the hot dry winds become a menace to the crop.

When the time for irrigation arrives, a V-shaped trench half-way between the rows should be opened in alternate middles with an 8 or 10 inch lister plow; that is, a narrow plow with a double moldboard which throws the dirt each way. In these furrows the irrigation water is run so that the soil will not become solidified by flooding, and the necessary amount of water may be properly distributed. For the second irrigation furrows are opened in the middles that were not opened at the first irrigation, and this alternation is continued for succeeding irrigations. At the head of each field is a feeder ditch from which the water is admitted to these irrigation furrows between the rows. It is essential that the right quantity of water be used, and that it be uniformly distributed. Cultivation should commence as soon after irrigation as the soil will permit so as to insure rapid and uniform growth without check. This will not only result in the production of smooth, uniform tubers of attractive appearance, which are always in demand at high prices, but will also result in large, profitable yields and at the same time keep the soil in good mechanical condition for future crops. Do not irrigate after August 10, so as to give fifty or sixty days for ripening in dry earth.

If great care and scientific methods are necessary for best results in the production of market potatoes, they are tenfold more important in growing seed stock for next year's planting. Uniform growth of tubers for seed purposes, without check in development, produces a seed potato of higher vitality than tubers of uneven growth; and the clean, smooth tuber with tough skin, free from clinging soil or dirt, keeps better and is freer from disease germs during the long season before next year's planting.

STORAGE.

Each year the storage of potatoes is becoming a subject of greater importance. The object to be aimed at in storage is to keep the potatoes at as low a temperature as possible without freezing, and at the same time keep the surrounding air as dry as possible. Potatoes should be pretty ripe when harvested, as skin-slip potatoes turn black, do not keep well, and are unattractive when exposed for sale.

While mining in the early days of Colorado, at an altitude of 12,000 feet, the writer met an old prospector who was going to leave the country. He said that in an old tunnel I would find some supplies, including 12 sacks of potatoes, which had been put there two years before, and which I might have. The condition of these potatoes was apparently the same as when they were dug; they were not shriveled, no shrinkage was apparent, the eyes were not swollen, and when cooked they were just as edible as when dug out of the ground. There had been an air shaft constructed at the end of the tunnel and through the tunnel was a good current of dry air. The temperature was about 40° F. When the writer came to build a potato cellar he tried to get as near those conditions as possible.

The cellar is 50 by 200 feet. At each end there is a dead-air space of about 10 feet in the form of a vestibule between the outer and inner doors which affords protection from freezing. There is a driveway clear through and on either side the bins are located, skylights and ventilators being placed every 10 feet. The temperature of the cellar may be lowered by opening the doors and letting a current of air pass through. When it is too cold for this, the ventilators at the top may be opened. The best ventilation is always secured by building the cellar in line with the direction of the prevailing air currents. During the winter the temperature should be kept as near 32° F. as possible; it should never go below 30° nor above 36°. Potatoes will not freeze until the temperature falls below 28° F. In the spring of the year, when the weather becomes warm, the cellar doors are kept open at night and closed in the daytime.

One important point in the storage of potatoes is to reduce the temperature to as low a point as possible directly after the product is stored. Put about 1 foot of potatoes on the cellar floor, and by the time the entire floor is covered to that depth the heat from those potatoes is pretty well carried off by the air currents. Then add another layer, thus properly regulating the temperature as the storage progresses. Ordinarily, when the cellar is filled the potatoes are piled about 5 feet deep.

MARKETING.

In deciding what kind of potatoes to plant, the grower should study the conditions and demands of the market. He should grow a medium-sized potato. On rich land the potatoes planted 8 inches apart in the row will yield not only a greater tonnage, but tubers of more desirable size. There are few markets, except in the South, that will pay a good price for large potatoes.

Our methods of packing and marketing potatoes have been, and are yet for the most part, more crude than those used with other products. By the time they get to the consumer they are more or less bruised or crushed. The writer has thought of crating potatoes and developing that idea in Denver and New York. At the present time he favors a 40-pound crate. This size may be increased or decreased to suit the market. The grower should cater to the demands of the most particular and exacting consumers. He should try to educate the public to appreciate the delicacy of a first-class potato. The grower need not be afraid of freight bills if he can furnish better potatoes than anybody else. Hood River has a reputation for apples that makes them cost more to the consumer on the eastern market than the eastern apples by two or three times. This reputation was gained by packing apples that did not have an imperfect specimen in a car. Do not put in a package a potato that you would not serve to a guest at your own table.

SELECTION OF SEED.

Of all the factors in potato growing, selection of seed is by far the most important. Some twelve years ago the writer undertook to improve and develop a potato along the same lines that he follows in improving his Shropshire sheep and Shorthorn cattle, using the best method of selection and giving the seed plat the best possible cultivation and irrigation in order to obtain uniformity of product. Since that time he has been selecting seed potatoes of the size and type which he wants to produce. As a 12-ounce potato is about ideal in size, seed potatoes of that size were selected from the bin in the spring and then 4 or 5 acres were planted in a special plat for seed, to be used for the main crop the following year. This plan was followed for twelve years with a potato (the Perfect Peachblow) which it was said would degenerate and ultimately run out; but that potato continued to improve during all that time.

Three years ago Prof. E. R. Bennett, a specialist in potato work from the East, came to our state agricultural college. He became interested in the work the writer was doing and freely complimented him on his success in potato production; but he wanted to take up and further improve the stock. Out of specially selected seed he selected perfect tubers and planted them in a field by themselves, and when the potatoes were ready to harvest we dug all of them by hand and kept the product of each hill separate. (See figs. 2 and 3.) All hills that did not have 20 tubers of uniform size, without knot, crack, or rough end were discarded. No hill was selected unless it came within these requirements, and surprisingly few hills were found which passed muster. Enough were selected, however, to make about 200 pounds, and these were planted the following spring. When harvested it was a most marvelous row of potatoes. By pursuing this method it is hoped soon to have a potato that will make 25 perfect tubers to the hill.

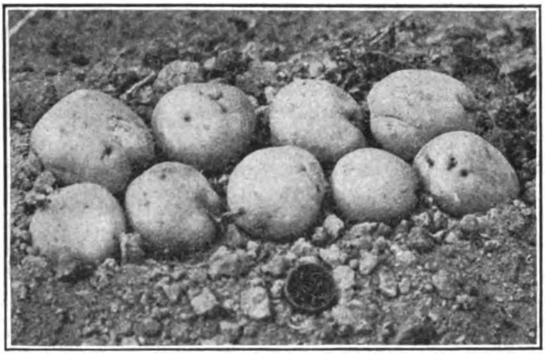
FIG. 2.—Product of a single hill, showing uniformity of size and shape resulting from hill selection of seed.

Had we bred our Shorthorn cattle as we have been in the habit of selecting and breeding our seed potatoes, we would now have no breed of Shorthorns. If we used only the culls and scrubs to breed from, our breeds of stock would soon run out. These breeds have been brought to their present standard by selecting the best on scientific principles of breeding. One reason why potatoes have degenerated in the past is that the potato growers of the United States have planted their culls and screenings under the erroneous impression that such methods in seed selection would produce as good results as any other.

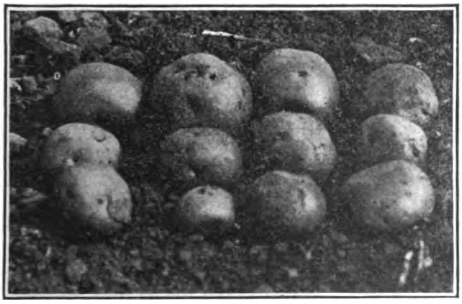
FIG. 3.—Product of a single hill, showing heavy yield and fair uniformity.

In selecting potatoes in the field, considerable dependence can be placed on the appearance of the tops. A large perfect top, with several stems of good shape and size, can be depended upon to have more tubers under it, and of more uniform quality and size, than a hill with a single stalk or one with small weak stems.

One of the essential and most important factors for success in this industry is the selection of perfect seed stock from the hill, in much the same way as seed corn is selected in the field from the best individual stalks. There is no other way to get true breed characteristics in potatoes except by selecting seed from the perfect hill, and seed should be saved only from hills producing a first-class marketable potato in the growing of which there is no waste of plant food. No manufacturer in this day of economy could stand the loss entailed by methods of manufacture under which he was compelled to cull out and throw in the scrap pile 20 per cent of his product as waste, and no one can expect the highest success in potato culture who adopts methods resulting in a loss of 20 to 60 per cent of his crop in culls and unmarketable potatoes. But this is what the potato growers of the United States are doing to-day.

VARIETIES.

Years of experience have demonstrated that comparatively few varieties of potatoes are really adapted to western or mountain conditions. Among the early varieties none has been so universally successful as the Early Ohio. This potato is of fine quality and uniform in size and shape, though not a heavy yielder. Another good potato, though not so early, is the Rose Seedling.

For a medium to late variety, the Dalmeny Challenge, a Scotch variety, is being used quite extensively on the western slope of Colorado. For later varieties, the White Pearl and Rural New York No. 2 are more extensively used at Greeley, in the San Luis Valley, and in the Uncompahgre Valley; and the Perfect Peachblow is the favorite in the upper Grand Valley. The latter variety has been grown continuously by the writer for twenty-five years, and under the system of seed selection already described it has become a much better and more perfect type of potato than it was ten, twenty-five, or even sixty-five years ago, when first introduced.

POSSIBLE YIELDS.

Mr. Dodge, of the United States Department of Agriculture, and the writer hunted for an hour in a field of good potatoes to find one perfect hill, and it was a marvel of perfection. There were 16 potatoes, not one under 6 and not one over 14 ounces, and the total weight of the hill was 8 pounds. Not one particle of wasted energy or soil fertility was represented in this hill; and by a series of years of seed selection of a perfect type and variety of potatoes, by the exercise of a knowledge of balanced plant foods and soil fertility, and by scientific cultivation and application of moisture by irrigation, such hills could be produced over practically the whole field.

Planting potatoes 12 by 36 inches apart will give 14,520 hills to the acre; allowing for a loss of 10 per cent on account of imperfect stand, there would still be 13,068 hills. At 8 pounds to the hill, this would make a total of 104,544 pounds to the acre. This is 18,656 pounds less than a field crop of potatoes raised by the potato wizard of Scotland, the Earl of Rosebery, who last year grew 123,200 pounds per acre total crop, with 105,280 pounds of marketable potatoes over a 1¾-inch screen. Some day potato growers may be expected to approximate this phenomenal yield in Colorado, as the conditions of climate, soil, heat, and application of moisture are much nearer ideal for potato production than in any part of Scotland.

CONCLUSION.

There is no line of farming in the irrigated districts that gives such marvelous profits as that of scientific potato production.

With scientific knowledge which can be acquired by experiments in supplying perfectly balanced plant food and maintaining soil fertility, the scientific principles of which are similar to those used by every successful breeder in feeding and fitting prize-winning stock; and with the proper proportions of plant foods—phosphates, nitrogen, and potash—in the soil as found in many parts of the West; and by the use of clover and alfalfa, there is no reason for those who contemplate engaging in the potato industry to fear the outcome.

Too much stress can not be put upon the value and importance of live stock in keeping up favorable soil conditions, as no country now known has been continuously successful in crop production without the use of manures from the feeding of forage and grain crops.

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them. Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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THE PRESERVATIVE TREATMENT OF FARM TIMBERS.

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THE PRESERVATIVE TREATMENT OF FARM TIMBERS.

INTRODUCTION.

The amount of wood used on the farms of the country and exposed to rapid decay is enormous. It is estimated that 1 billion fence posts and rails, the equivalent of 6 billion board feet, are required each year. For this class of material durability is the first requisite. The naturally durable woods were formerly plentiful over large areas, but in many sections they have now become too scarce and dear to use. There remains, however, an abundance of inferior woods which, when preserved from decay, are entirely satisfactory substitutes.

Many different preservatives have been widely used for ties, poles, and piling. The scarcity of durable fence posts is, however, comparatively recent, and definite information regarding the preservative treatment of fence posts has naturally been lacking. A series of experiments to determine the best manner of creosoting posts of various inferior woods was, therefore, undertaken by the Forest Service in cooperation with the following States and agricultural institutions: The Commissioner of Agriculture and Industries of the State of Alabama, Montgomery, Ala.; the Alabama Polytechnic Institute, Auburn, Ala.; the North Louisiana Agricultural Experiment Station, Calhoun, La.; the Maryland Agricultural Experiment Station, College Park, Md.; the South Carolina Agricultural Experiment Station, Clemson College, S. C.; the Ames Experiment Station, Ames, Iowa; and the University of Minnesota Experiment Station, St. Paul, Minn. These organizations heartily supported this work, and to their cordial cooperation is due much of the information that has been acquired.

DECAY AND METHODS OF PRESERVATION.

Decay consists in the destruction of the wood tissues by low forms of plant life. These organisms we term fungi. It is possible that bacteria may be associated in some cases, but as yet we have no positive proof of it. It follows that the object of all preservative treatment is to prevent the development of these organisms, and that the most effective treatment is the one that accomplishes this for the longest period.

Fungi require for their best development a certain balance between the air and the moisture content of the wood, and a favorable temperature. Thorough seasoning, on the one hand, or thorough saturation with moitsure on the other, alters this balance to such an extent that the growth of the organism is either retarded or prohibited. Air seasoning only retards the growth.

There are several methods by which timbers may be given more thorough preservative treatment. The surface of the wood may be soaked with paint or some similar substance. Such a coating keeps the wood dry, and more or less effectually excludes the entrance of the decay-producing organisms. Such coatings, however, should be applied only to well-seasoned material, since they will also tend to retard the escape of such moisture as may be already within the timber. Better preservatives are the products of the distillation of coal tar and petroleum tar, which, in addition to possessing the advantages of paint, are antiseptics and poisonous to fungi. The deeper such antiseptics penetrate the wood the more lasting is their effect.[a]

It is well known that wood decays most rapidly when placed in contact with the surface of the ground, because the wood-destroying organisms find there more uniform conditions of heat and moisture to encourage their development. For this reason the ground line of a post must be thoroughly treated, whereas portions of the post above and below this point require less treatment. The climate of the locality should also be considered. In the warm Gulf States or in a moisture-laden atmosphere posts require more thorough treatment than in a cooler northern climate or on the arid plains.

PROLONGING THE LIFE OF POSTS.

The usual methods of prolonging the life of fence posts are here considered in the order of their efficiency, beginning with the cheapest and least effective. One point deserves special emphasis, namely, that in spite of the high first cost, the best treatment is the most economical in the long run. The study upon which this publication is based indicates that impregnation with creosote is decidedly the best preservative method.

SIMPLE METHODS.

Peeling and seasoning.—The value of seasoning has already been explained. It is likewise important to remove the bark, so that the outer layers of the wood may dry more thoroughly.

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[a] See Forest Service Bulletin 78, "Wood Preservation in the United States," by W. F. Sherfesee.

A preservative method, akin to seasoning, consists in piling stones or similar material around the base of the post. This checks the growth of weeds and permits the air to circulate more freely around the post. It is doubtful, however, whether the saving justifies the cost.

Charring.—Good results have been obtained by charring the post over an open fire. The wood must first be thoroughly seasoned, and care must be taken not to let the wood "check" or split from the heat. Too deep charring, which will weaken the post, must obviously be avoided. In some cases it is unnecessary to char the entire post, but the burning should always extend 1 foot above and 1 foot below the ground line. It is often a good plan to char the very top of the post.

Painting.—Treatment with the brush should be resorted to only when more efficacious methods are impracticable. If brush treatments are to be effective, the posts must have been thoroughly seasoned, or the surface coating will afterwards be broken by the opening of seasoning checks through which moisture will enter the wood. At best surface coatings are not very durable. Some of the substances which may be applied with a brush are whitewash, petroleum-tar creosote,[a] coal-tar creosote,[b] and various patented products of coal tar and petroleum tar. Paint and whitewash are inferior to antiseptic preservatives; products of coal tar (creosote, etc.) are the best. These are best applied hot, in two or more coats. A barrel (50 gallons) of creosote should be sufficient to paint at least 300 posts with three coats for the butts and two for the tops.

Dipping.—One defect of brush treatment is that the preservative does not enter readily the cracks and checks. This defect may be overcome by dipping the posts in the preservative. Another advantage of dipping, as compared with painting, is a saving in labor. On the other hand, dipping requires a larger quantity of preservative, and, in addition to the amount consumed, there must be enough surplus to keep the barrel or tank filled to the proper depth. This usually forbids the use of any expensive preservative for dipping. Petroleum tar, coal tar, and the creosotes, however, may often be advantageously employed.

Posts have been treated by dipping the butt in cement. This is hardly satisfactory, owing to the ease with which the protective covering may be broken; moisture is absorbed after treatment and causes the wood to expand and crack the cement.

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[a] Petroleum-tar creosote is derived from petroleum tar, which is a by-product of the manufacture of water gas. It is possibly not so efficient a preservative as coal-tar creosote, but it may be used with good results and is often cheaper.

[b] Coal-tar creosote is a derivative of coal tar, which is a by-product in the manufacture of coal gas and of coke. Its price is comparatively low.

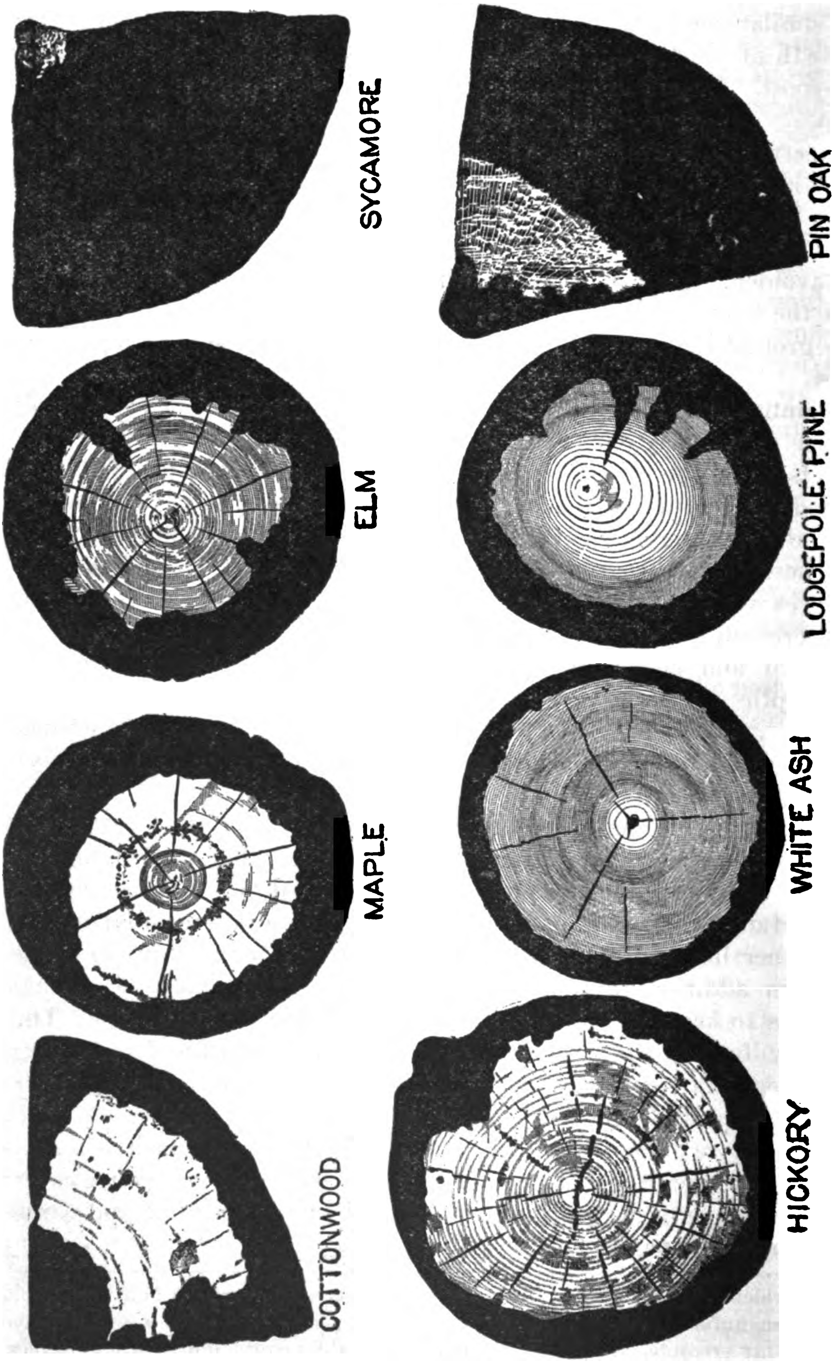

FIG. 1.—Sections of posts of various woods treated with creosote by the open-tank process. All the posts are drawn to the same scale, and are approximately 5 inches across. The black areas show the creosote penetration, which corresponds generally to the sapwood.

Cold-bath treatment.—The treatments thus far considered merely coat the surface with a preservative. Penetration or "impregnation" of some woods is secured by prolonged soaking (a ten-hour bath) in the preservative at ordinary air temperature. This method of treatment is attractive in many cases, because it is so simple. Nevertheless, far better results are obtained in all cases by the use of a hot bath as well as a cold bath. As a rule only the cheaper preservatives can profitably be used in the cold-bath treatment, for the same reason as in dipping. Coal tar is so ropy and sticky that it will scarcely penetrate even the most easily treated woods. Crude petroleum enters the wood rather readily but lacks strong antiseptic qualities. A long bath in crude petroleum may, however, prove a feasible method of treatment where petroleum is very cheap and the woods used are readily impregnated. Creosote is usually the best preservative to employ. Coal-tar creosote requires a slight heating to liquefy it.

Water in the wood cells resists the penetration of the oil. Thorough seasoning before treatment is, therefore, necessary to allow the oil to penetrate readily and to prevent checking after treatment.

The cold-bath method of treatment has not yet been thoroughly investigated. It is probable, however, that it will impregnate but few woods. The woods which are likely to prove most suitable are beech, cottonwood, the gums, pin and red oaks, the pines, sycamore, and tulip tree.

IMPREGNATION WITH CREOSOTE.

Method of treatment.—The impregnation of fence posts with creosote is best accomplished by the so-called "open-tank" process.[a] This consists of heating the wood for a certain period and then cooling it in the preservative. The principle is simple: During the heating the high temperature causes the air and water contained in the wood cells to expand, so that a portion of this air and water is forced out. The rest contracts as the subsequent cooling progresses, and a partial vacuum is formed, into which atmospheric pressure forces the cool preservative. Figure 1 shows sections of posts treated in this manner.

The open-tank principle may be variously applied in the treatment of posts. The best way to heat the posts is to immerse their butts in creosote maintained at a temperature of 220° F. If a single tank is used the cooling bath may be given by permitting the temperature to fall, and in this case the preservative must, of course, be used for the hot bath. It is better, however, to employ an additional tank containing the cold preservative. If two tanks are used and a thorough impregnation of the top of the post is desired, the cold-bath tank should be large enough to permit the soaking of the entire post. The top of the post will not be too heavily impregnated, because it has not been immersed in the hot oil. Creosote is usually the most satisfactory preservative. With two tanks crude petroleum or any heavy (high-boiling) oil may be used in the hot-bath tank.

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[a] So designated to distinguish it from the "closed" or "pressure" cylinder process which is often employed in creosoting ties and piling.

Forms of treating tanks.—The simplest form of treating plant is shown in figure 2. It consists of two creosote barrels, placed about 7 feet apart and connected by a 3 or 4 inch pipe. The heating is accomplished by building a fire under the pipe. This outfit is, in some particulars, unsatisfactory. It is certain to leak after a few days, and, in addition, the shallowness of the barrels is a serious disadvantage. Nevertheless, the barrel outfit may suffice when only a few posts of readily impregnated wood are to be treated and when, in consequence, the treatments are few and short. To lessen the danger of leakage the pipe should be fitted with lock (jam) nuts. Further, the barrels should be shielded from the direct heat of the fire. Each barrel should be set in a shallow box or provided with some gutter arrangement to catch the oil in case of an unexpected leak. A U of 1½-inch pipe, as shown in figure 3, may be used in heating a single barrel.

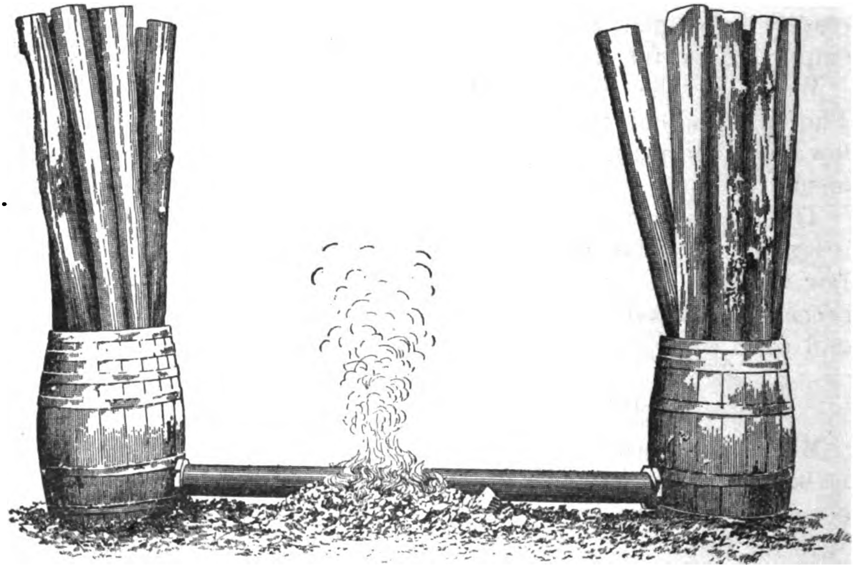

FIG. 2.—Barrel outfit.

The apparatus shown in figure 3 will probably be of most general value. The method of heating used for the barrel outfit is here applied to a light (14 gauge) galvanized-iron tank. A cylindrical tank, 3 feet in diameter and 4 feet high, fitted with a U of 3-inch pipe, can be purchased for $12 to $15. This cost is very reasonable when the permanency of the outfit is considered.

In the method of heating illustrated in figure 4 a black iron tank is used, and the fire is built under it. A fire box and a hot-air chamber are constructed with brick, and a sheet-iron collar caps the masonry. The tank is supported by a strong foundation. Such an outfit, with a tank 3 feet in diameter and 4 feet high, made of $\frac{3}{16}$-inch black iron, would probably cost from $25 to $30. The tanks used by the Forest Service are shown in figure 5. These are heated by steam and prove satisfactory. The two tanks and the necessary piping cost $50.

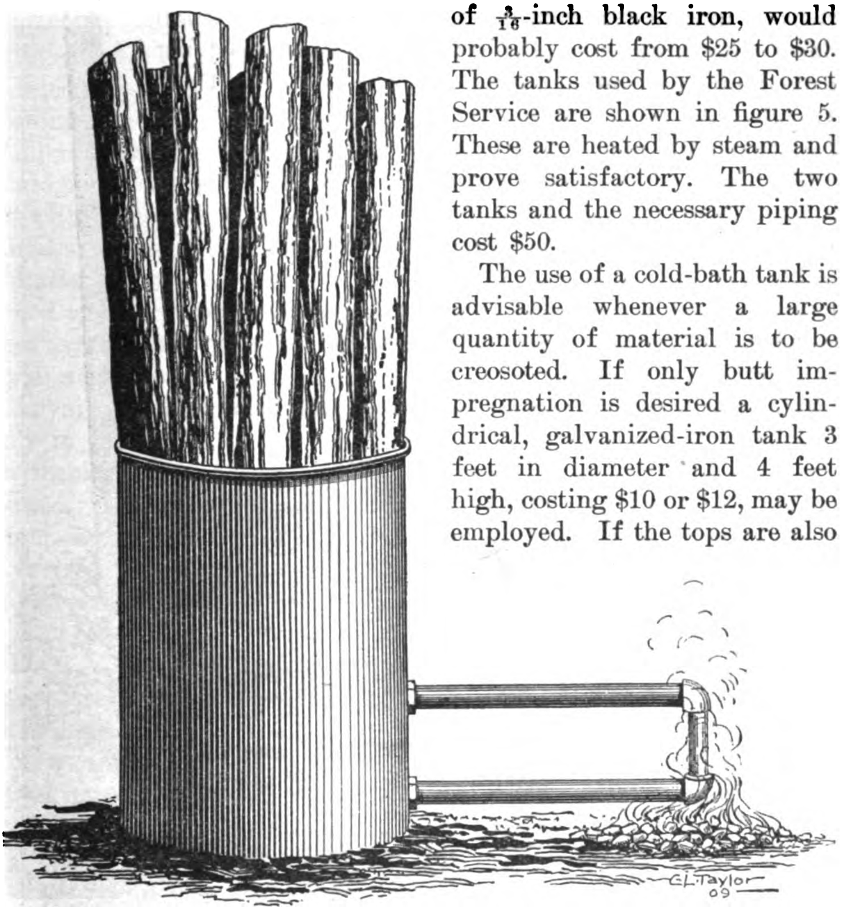

FIG. 3.—Light iron tank heated by the pipe method of direct heating.

The use of a cold-bath tank is advisable whenever a large quantity of material is to be creosoted. If only butt impregnation is desired a cylindrical, galvanized-iron tank 3 feet in diameter and 4 feet high, costing $10 or $12, may be employed. If the tops are also to be impregnated the tank should be rectangular, 8 feet long, 3 feet wide, and 3 feet deep. Such a tank would cost approximately $20. Provision must be made for slightly heating the cold-bath tank, since creosote is often solid at atmospheric temperature. Best results are obtained at a temperature of 100° to 120° F. A thermometer reading to 250° F. is a necessary part of every equipment.

Preparation of the posts for treatment.—For treatment with creosote some importance attaches to the size and the form of the posts. The removal of the bark and the seasoning of the wood before treatment are essential for success. At present many posts of large size are used in order that the strength of the fence may still be sufficient after decay has progressed for several years. Obviously such large posts are unnecessary if proper preservative treatment is given, and, since the cost of treatment increases rapidly with the size of the post, there is much advantage in using comparatively small ones. For instance, a well-treated line post need not exceed 5 inches average diameter. The figures in Table 1, "Recommended treatments for various woods," are based on posts of this size.

The form of the post, whether it is round or split, may influence the efficiency of the treatment. A split post necessarily has heartwood exposed to the air. With some woods this is immaterial; with others the heartwood can not be impregnated, and untreated heartwood will prove inferior in durability to properly treated sapwood. Therefore, only round posts of the latter class should be used. In general, the heartwood that is highly colored, such as that of oak and yellow pine, is practically impenetrable.

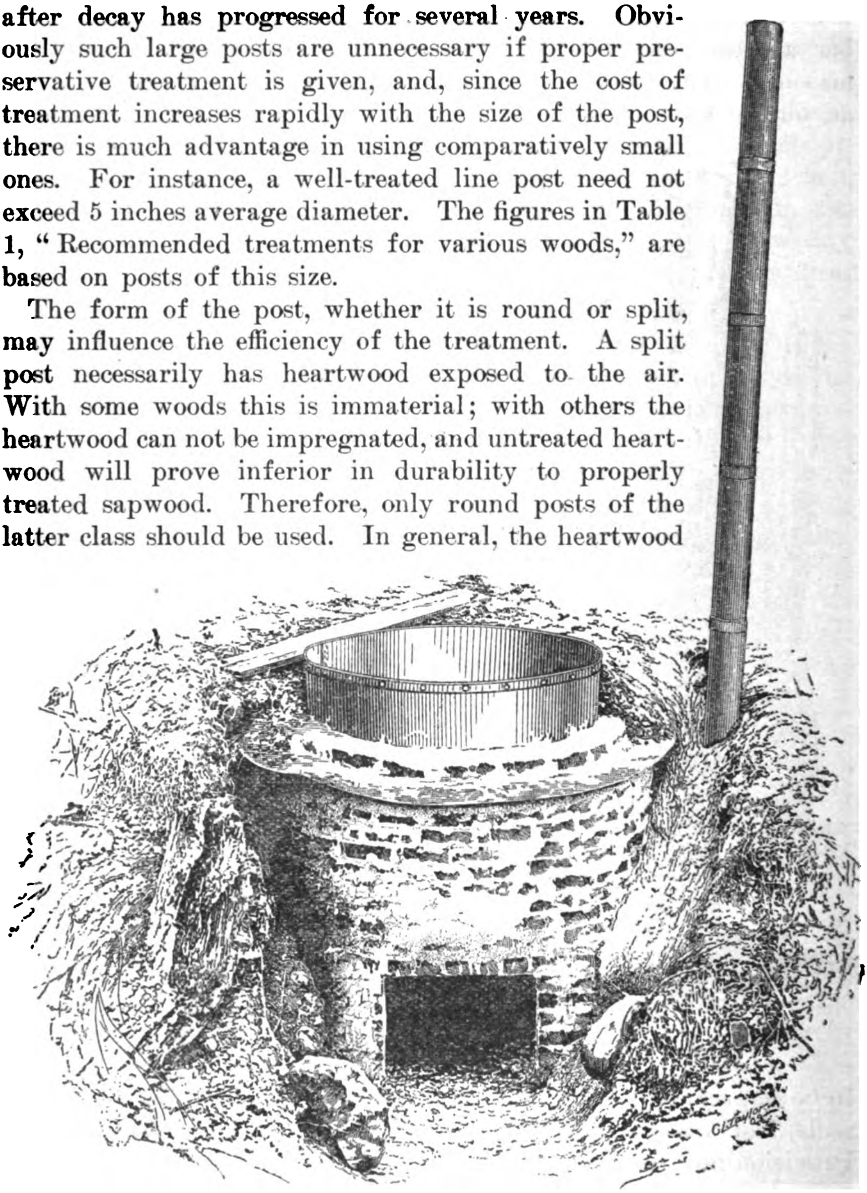

FIG. 4.—Heavy iron tank heated by fire underneath.

The tops of the posts should be cut obliquely to shed rain water. A bevel made with an ax is preferable to one made with a saw, because it is smoother. Beveling is particularly important if the tops of the posts are not to be treated.

Bark retards or prevents the penetration of the preservative into the wood. It also uselessly increases the cost of treatment by itself absorbing oil. Peeling the posts before treatment is, therefore, necessary. Even the papery inner bark should be carefully removed, especially in the case of pine and basswood.

Thorough seasoning should always precede impregnation. Even air-dry wood is unfit for treatment after a heavy rain, and when thus saturated should be permitted to dry for at least three days of good seasoning weather.

Under favorable conditions the average period required to season posts is five weeks, but this period varies widely, according to the kind of wood, the season of the year, and climatic conditions. A simple method of determining the degree of seasoning is to weigh a few representative posts every few days. As a rule, an air-dry condition is reached when the loss of moisture is less than 1 pound per post (of 5 inches average diameter) during five days of good seasoning weather.

Application of the preservative.—It is well known that different woods vary greatly in weight and strength. They also differ considerably in the ease with which they absorb the preservative; so that each species requires a different treatment if best results are to be obtained. In the experiments conducted by the Forest Service and its cooperators the purpose has been to determine the best treatment for various woods. The investigations have also indicated the relative ease of treatment of the different woods. Two methods of treating were employed. In some cases but one tank was used, and only the butts of the posts were impregnated, though two tanks were used in creosoting most of the woods. In the second method only the butts were immersed in the hot bath, while the whole posts were submerged in the cold bath.

Most species will absorb too much creosote if a very long treatment is given. Therefore, to make the treatments economical the absorption must be limited to 0.4 gallon per post if only the butt is treated, or 0.6 gallon per post if the top also is impregnated. The best treatment is that which will give, with a reasonable absorption, the deepest possible penetration of the oil into the wood in the shortest time.

Woods which are naturally durable in contact with the ground, such as cedar, locust, white oak, and black walnut, were also included in the experiments. In general, a heavy treatment is required to impregnate their sapwoods, and their heartwoods can not be successfully treated. Though preservative treatment somewhat prolongs the life of these species, they are not only too expensive to be treated with economy, but even without treatment they are likely to cost more than cheaper and equally satisfactory posts that can be had by creosoting an inferior wood.

In California, posts of different species of eucalyptus were creosoted. A three-hour bath in hot oil was a sufficient treatment for green posts, but the oil penetrated very irregularly. When the posts were inverted after butt treatment, the free oil followed the large ducts in the wood and appeared on the top of the post. A few tests also were made on quaking aspen, boxelder, Douglas spruce, and silver maple. Quaking aspen will probably require a treatment similar to that recommended for cottonwood. The heartwood of Douglas spruce is impenetrable by open-tank treatments, but the sapwood may be easily impregnated. Boxelder and silver maple absorb creosote readily, but the penetration at the ground line is relatively small.

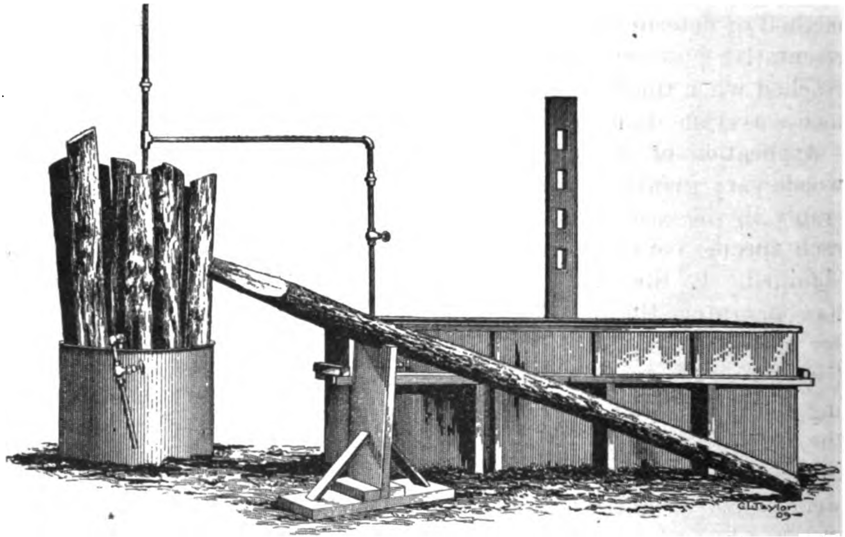

FIG. 5.—Experimental outfit heated by steam. The rectangular horizontal tank is for the cold bath.

Therefore, whenever a choice of species is possible, only the woods best adapted to preservative treatment should be used. The relative fitness of several of the commoner kinds of wood is shown in Table 1. Yet, because of the different methods used, this table can not be depended upon to give the exact length of treatment in each case. It is easy, however, to find the best treatment in any particular instance. With well-seasoned material the absorption is indicated by the difference in the weight of sample posts before and after treatment. Pounds may be converted into gallons by dividing by 8.5. The penetration at the ground line may be gauged by boring with an augur or chipping with an ax. Surfaces thus exposed should be well coated with creosote before the post is set. If the first treatment is not satisfactory, better results can be obtained by varying the lengths of the hot and cold baths. If the penetration is insufficient the period of heating should be increased; if the penetration is satisfactory, but too much oil is absorbed, the cold bath should be shortened.

TABLE 1.—*Best results secured in the treatment of various woods.*

[All posts were round, peeled, and seasoned.]

Species.	Absorption per 5-inch post.	Penetration.		Single-tank treatment.			Double-tank treatment.	
		2 feet from butt.	2 feet from top.	Butt.		Top.	Hot oil.	Cold oil.
				Hot oil.	Cooling oil.			
	Gallons.	*Inches.*	*Inches.*	*Hours.*	*Hours.*		*Hours.*	*Hours.*
Ash, white	0.4	0.4		5	12	Dipped[a]		
Basswood	.6	.1	0.05				1	½
Beech	.6	1.0	.4				1	¾
Birch, river	.6	.7	.3				3	1
Butternut	.4	[b].5		6	12			
Cottonwood	.4	.6		1	12	Dipped[a]		
	.6	.3	.1				1½	1
Elm, slippery	.6	[b].3	.1				1½	1½
Elm, white	.4	[b].4		6	12			
Gum, black	.6	.6	.3				1	1
Gum, cotton (tupelo)	.6	.6	.3				1	1
Gum, sweet (red)	.6	1.0	.3				1	¾
Hickory, bitternut	.4	.5		6	12	Dipped[a]		
Magnolia, sweet (bay)	.6	.4	.2				1	½
Maple, red	.6	1.0	.3				4	2
Maple, sugar	.6	.2	.1				3	2
Oak, pin	.5	[b]1.0	.5				1	¾
Oak, red	.4	[b].5	.3				1	¾
Pine, loblolly	.5	1.5	1.0				1½	1
Pine, lodgepole	.6	1.2	.6				1½	1
Pine, pitch	.5	1.0	.3				3	1
Pine, scrub	.5	1.0	.4				3	2
Pine, shortleaf	.5	1.0	.3				3	1
Poplar, white	.5	.5	.2				6	12
Sycamore	.6	1.0	.2				1	½
Tulip-tree	.6	.4	.1				2	½
Willow, white[c]	.6	.6	.2				4	1

[a] Dipped for 5 minutes or more.

[b] Width of sapwood. Penetration limited by impenetrable heart.

[c] Requires especially thorough seasoning.

The procedure in treating may be summarized as follows:

(1) Raise the temperature of the hot bath to 220° F. before putting the posts in the tank. Maintain this temperature throughout the bath. Have sufficient oil in the tank to submerge the butts 6 inches higher than the ground line when the posts are set.

(2) If only one tank is used, the oil will be absorbed by the posts during the cooling bath, and more should be added to keep them submerged to the proper depth.

(3) If two tanks are used, liquefy the cold bath by heating. The best temperature is from 100° to 120° F. Transfer the posts from the hot to the cold bath as quickly as possible. At least that portion of the post which has been heated should be immersed quickly in the cold bath.

Cost of treatment.—General cost figures are valueless, but the cost under any specified conditions may be readily ascertained. Apparatus and oil are the two most important items of expense. The charge per post for the apparatus should not exceed 1 cent when a serviceable outfit is used and its permanency is considered. Labor and fuel charges are usually ignored in fence-post treatments, and hence are omitted in the examples of cost given below. If, however, it is desired to include them, the number of posts treated daily is important. Of course the size of the post affects the cost.

The cost of creosote by the barrel varies widely according to locality. In the Eastern States it costs 12 to 15 cents per gallon; on the Pacific coast, 15 to 20 cents; in certain localities in the Rocky Mountain region it is as high as 30 cents. In Table 1 the absorption of oil per post is stated for the recommended treatment. To this must be added a certain quantity of oil which evaporates from the hot bath. The amount of creosote which evaporates depends mainly upon the grade used, but 20 per cent of the absorption is accepted as the average. The quantity of oil consumed per post is, therefore, one and one-fifth times the absorption.

Table 2 shows the cost of treatment under certain conditions.

TABLE 2.—*Cost of treatment per post under certain known conditions.*

	Items of cost.				Cost of treated post.
	Post.	Treating plant.	Creosote absorbed.	Creosote volatilized.	
Loblolly pine (Louisiana) or scrub pine (Maryland); entire post impregnated; creosote, at 15 cents per gallon	$0.05	$0.01	$0.08	$0.01	$0.15
Quaking aspen (Maine) or cottonwood (Minnesota); butt impregnated; top dipped; creosote, at 12 cents per gallon	.05	.01	.05	.01	.12

Value of treatment.—In portions of Maryland locust posts cost 35 cents apiece, and are difficult to obtain even at this price. A pine post, treated in the manner recommended in Table 1, will doubtless equal one of locust in durability, and will cost only half as much. In the prairie region of Minnesota willow posts of sufficient size to last fifteen years cost 25 cents. Creosoted cottonwood posts could be substituted for these, and would be considerably cheaper as well as more durable. In sections of Idaho lodgepole pine posts are extensively used. Table 3 illustrates the annual saving effected by creosoting such posts.

Table 3.—*Comparative costs of untreated and treated posts of lodgepole pine in Idaho.*

	Untreated.	Treated.
Initial cost of post	$0.06	$0.06
Cost of treating post	.00	.15
Estimated cost of setting post	.12	.12
Total cost of set post	.18	.33
Estimated length of service ......years	4	20
Annual cost of post (allowing 6 per cent interest on investment) approximately	$0.05	$0.03
Annual saving per post treated	....	.02

In general, it may be said that any post properly creosoted will last twenty years. To determine the exact length of life under various conditions, posts experimentally treated are being tested in fences, and detail maps on which each post is numbered are made to record the kind of post and its treatment. By means of such maps it is possible to study the durability of the individual posts and the effects of various treatments under different conditions.

PROLONGING THE LIFE OF SHINGLES.

Wood used on the farm in various forms other than post material may often be advantageously preserved from decay by chemical treatment. The results obtained assuredly justify the cost of treating all timbers used in foundations, sills, beams, and planking, as well as the lower portions of board fences, and the lumber used near the ground in sheds and barns. The treatment of these is very similar to that given posts. Shingles, however, form an important special class of material.

With the grades of shingles obtainable nowadays exposure to rain and sun commonly results in warping or curling. Water absorbed during a storm subsequently evaporates rapidly from the upper surface and rather slowly from the lower surface. Consequently, the upper part of the shingle shrinks more than does the under, and curling or warping results. The importance of excluding moisture is obvious. In addition to this, it is advisable to employ an antiseptic to retard decay. The best preservative, it follows, must possess such qualities as will operate in both these ways to prolong the life of the shingles.

The necessity of applying preservatives only when the wood is thoroughly dry may again be emphasized.

NONANTISEPTIC PRESERVATIVES.

The application of paint is the preservative measure most commonly used with shingles. The method of applying it is of paramount importance. Dipping the shingles individually is the only satisfactory procedure. When a roof is painted ridges of paint are formed at the bases of the shingles, owing to the irregularities of the surface over which the brush passes. These cause the water to permeate the crevices between the shingles and frequently hasten decay.

ANTISEPTIC PRESERVATIVES.

The best antiseptics for shingle treatment are creosote and other derivatives of coal tar. Painting the roof with these oils is a rather satisfactory method of treatment, since the coal-tar derivatives penetrate the shingles better than ordinary paint and do not leave ridges below the base of the shingles. At least two coats should be applied. Dipping the individual shingles gives good results. The best results are, however, obtained by heating and cooling the wood in the preservative, as described for the treatment of fence posts. Sap loblolly pine shingles may be thoroughly impregnated by means of the open-tank process. This method is the best even for woods which resist the penetration of the oil; for example, white cedar. Its advantages are two-fold—the shingles can be treated in bundle form, and, with proper treatment, the surface of the wood will be free from surplus oil.

The open-tank process has already been explained. The apparatus used for posts may be employed, or if shingles exclusively are to be treated the form of the outfit may be modified. The simplest apparatus is a single tank large enough to hold a bundle of shingles. If a larger capacity is desired, the depth rather than the width should be increased, for, in order to minimize the loss from volatilization, the oil surface exposed to the air should be kept as small as possible. The best treatment for various kinds of shingles has not yet been determined. The proper length of treatment may, however, be readily decided in any particular instance by weighing the shingles before and after treatment. An absorption of 12 or 13 pounds per bundle, or 6 gallons per thousand shingles, is advisable. The cost of treatment per thousand shingles should range from $1.25 to $1.50. In order that the deepest penetration compatible with this absorption may be secured, the heating should be relatively long.

Creosoted shingles possess certain objectionable qualities, though none which prohibit their use. Among these may be mentioned their strong odor and their contamination of cistern water. Further, since the shingle nails become covered with creosote and can not be held in the workman's mouth, it is said to be more difficult to lay these shingles. The odor, however, disappears in the course of a few weeks—two weeks in one case observed; the contamination of the cistern water is also of short duration—in one instance the water was tasteless after three days of rain; and, in any case, the water from a newly creosoted roof can be diverted from the cistern for a week or so, or until there is no danger of making the water taste, and the use of a shingle-nailing machine obviates the difficulty in laying the shingles. All these objections are removed if the shingles are seasoned for a few weeks between treating and laying.

It is impossible to paint creosoted shingles satisfactorily; hence, if the brownish shade of the creosote is deemed undesirable, it is necessary to stain the shingles during the preservative treatment. Of the common colors green pigment is expensive and red and brown are cheaper. Further, it is necessary to use a comparatively large quantity of green to obtain a satisfactorily colored creosote, while a relatively small amount of red or brown pigment suffices. For these reasons it is not feasible to stain shingles green by the open-tank method of creosoting, and brush treatment or dipping must be resorted to. The latter two methods may also be used with a variety of patented stains containing creosote.

To obtain a red or a reddish-brown creosote 8 to 12 ounces of "color ground in oil," mixed with an equal bulk of linseed oil, should be used for each gallon of preservative.

CONCLUSION.

In many localities the need for the preservative treatment of farm timbers is imperative. Throughout wide areas the advisability of using creosoted posts is indisputable. In spite of these facts it is often difficult for a farmer efficiently to treat his own material with preservatives. This, however, does not indicate that the work should be neglected. Rather it points to some different means of securing the desired result. There are two practical methods of doing this. One is for some individual to undertake the work for the neighborhood. A small wood-preserving plant could be profitably operated in connection with a thrashing outfit, a feed mill, or sawmill. The other plan is for several farmers to cooperate in establishing and operating the plant. As an indication of the success which should attend such an undertaking the cooperative creameries of various sections of the country may be cited. The means, then, may vary, but it can not be too strongly emphasized that every agricultural district should possess the facilities for increasing, by preservative treatment, the durability of farm timbers locally used.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 388.

Experiment Station Work,

LVI.

Compiled from the Publications of the Agricultural Experiment Stations.

INCOMPATIBLES IN FERTILIZER MIXTURES.
PRINCIPLES OF DRY FARMING.
METHODS OF SEEDING OATS.
ROLLING *v.* HARROWING WINTER WHEAT.
DESTRUCTION OF EELWORMS IN SOIL.
PRUNING.
BEAN ANTHRACNOSE OR POD SPOT.
ANIMAL FEEDS FOR FARM STOCK.
FEEDING THE PIG.
JELLY AND JELLY MAKING.

JANUARY, 1910.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

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1910.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

INCOMPATIBLES IN FERTILIZER MIXTURES.

In a previous bulletin of this series[b] the danger of indiscriminate mixing of fertilizing materials was briefly explained, and a diagram was given which indicated what combinations may be safely made of some of the more common fertilizing materials. Figure 1 is a somewhat more elaborate diagram of the same kind, including, in addition to the materials shown in the simpler diagram, bone meal and the new nitrogenous fertilizers, lime nitrogen (calcium cyanamid) and Norwegian nitrate (basic calcium nitrate), prepared from the nitrogen of the air. In this diagram the dark lines unite materials which should never be mixed, the double lines those which should be applied immediately after mixing, and the single lines those which may be mixed at any time.

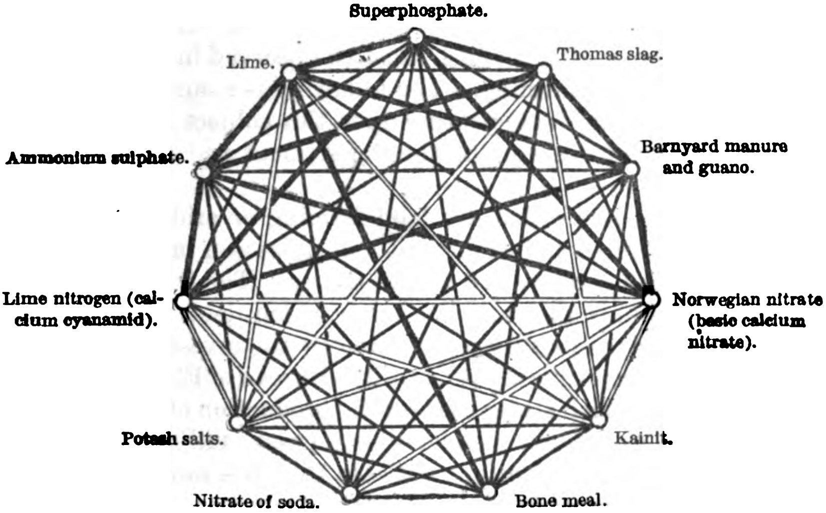
Superphosphate.
Thomas slag.
Lime.
Ammonium sulphate.
Barnyard manure and guano.
Lime nitrogen (calcium cyanamid).
Norwegian nitrate (basic calcium nitrate).
Potash salts.
Kainit.
Nitrate of soda.
Bone meal.

FIG. 1.—Diagram indicating what fertilizer materials may and may not be safely mixed. The dark lines unite materials which should never be mixed, the double lines those which should be applied immediately after mixing, and the single lines those which may be mixed at any time.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] U. S. Dept. Agr., Farmers' Bul. 225, p. 7.

PRINCIPLES OF DRY FARMING.[a]

The importance of extending the productive area of farm lands in the United States has been especially emphasized in recent years, with the result that much land hitherto considered unsuited to farming has been brought under cultivation. In this class are the large areas in the western half of the United States, where the rainfall is deficient. It was evident that if these lands were to be profitably utilized for agricultural purposes other than grazing, new methods of farming must be adopted. With this object in view, this Department and several of the experiment stations situated in arid or semiarid regions have carefully studied the agricultural conditions and possibilities of these regions and made extensive tests of the crops and methods of culture adapted to them. These investigations, as well as the practical experience of settlers on dry lands, have now gone far enough to make it possible to lay down some general principles and to indicate certain methods which must be observed in order to guard against failure in dry farming. The following is a summary of some of the more important facts bearing upon this subject as brought out by recent reports of this work by the Department and the experiment stations:

Dry farming is also called dry-land farming or arid-land farming. It is generally defined as farming without irrigation in regions where the annual rainfall is between 8 and 20 inches. The fact that rainfall alone is not the only moisture condition which determines the crop production of a given locality is indicated by the investigations of the Office of Forage Crop Investigations of the Bureau of Plant Industry of this Department, which states that for the production of such drought-resistant crops as alfalfa, slender-wheat grass, tall-oat grass, and brome grass the "investigations indicate that the minimum rainfall is approximately 16 inches in the Dakotas, 18 inches in Nebraska, 20 inches in Kansas * * * and up to 30 inches farther south." In other words, to produce a given crop the amount of rainfall necessary is much greater in the warmer regions, where evaporation removes so much moisture.

Dry farming is made possible in two ways: (1) By careful tillage, and (2) by the introduction of drought-resistant crops or drought-resistant varieties. Even where dry farming is followed, irrigation is usually recommended for the small areas to be devoted to garden crops to carry the household through years of crop failure, which are more frequent in these semiarid regions than in regions where the rainfall is greater.

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[a] Compiled from Montana Sta. Bul. 74; Nebraska Sta. Bul. 109; Washington Sta. Popular Bul. 15; Wyoming Sta. Bul. 80. See also U. S. Dept. Agr., Farmers' Buls. 262, p. 15; 329, p. 10.

The principles of tillage are almost exactly the same as for other regions, or even for the semiarid regions where irrigation is practiced, with emphasis laid upon the conservation of moisture: (1) Because the supply is low, and (2) because one and one-half times as much water is required to produce a pound of dry matter in the plant in these drier regions as is required in more humid climates.

Surface cultivation is constantly resorted to in order to maintain a mulch or lid to prevent the escape of mositure and to keep down weeds, which drain the land of its water. This mulch is renewed as soon as possible after each rain, but should not be made sufficiently fine to allow the wind to blow the soil from place to place. This is especially to be guarded against on sandy soil, which should be worked sooner after rain has destroyed the mulch than the clay soil, which is more inclined to puddle, bake, or otherwise get out of good physical condition. The third advantage arising from frequent surface cultivation is the admission of air to the roots of the crops supplying them with oxygen. This air also encourages the growth of the friendly bacteria which prepare plant food by breaking down humus and forming the nitrates which can be readily taken up by the roots of the plants.

Small shovels are usually preferred to larger shovels: (1) Because they do not ridge the soil and so leave a smaller surface to give up moisture to the sun and winds; (2) the greater number of shovels stirs the soil more uniformly in the shallower zone reached; and (3) because of their failure to go as deeply as the larger shovels there is less danger of root pruning. The disadvantage of the small shovel arises from its lack of efficiency in killing larger weeds.

In extreme cases it is necessary to store up two seasons' rainfall to be used for a single crop. This is usually done by summer tillage or clean summer-fallow, which differs from the old system of summer-fallowing in allowing the land to lie for a longer period unused, and in the more perfect maintenance of the surface mulch and exclusion of weeds. Summer tillage not only stores the water for future use, but also brings the soil into the best physical condition for the reception of the fall-sown crop, which is most frequently recommended for the semiarid regions.

The North Platte Station in Nebraska finds that summer tillage will store water weighing 15 per cent or more than one-seventh as much as the upper 6 feet of the soil. This is equivalent to about 14 inches of rainfall, and will give a fair crop of wheat even with a very low rainfall the following season. During the season of 1908 this station was able to hold only 50 per cent of the rainfall.

The Washington Station has found that 40 bushels of wheat per acre can be produced with 12 inches of water, and that if 50 per cent of the precipitation for two years can be saved a yield of 30 bushels per acre can be obtained with an annual rainfall of 10 inches upon the same land which produced 40 bushels with 12 inches of water and under equally favorable conditions. Fifty bushels of wheat were similarly produced by saving the same percentage of a 15-inch annual rainfall. The comparative results of continuous cropping and summer fallowing, as obtained in Montana, are best summarized by the following table:

Average results for all years tested.

Substation.	Kubanka spring wheat.		White hull-less barley.		Sixty-day oats.	
	Grown continuously.	After fallow.	Grown continuously.	After fallow.	Grown continuously.	After fallow.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dawson County	15.18	17.57	15.97	20.90	31.17	51.00
Rosebud County	16.98	20.80	15.02	28.31	30.21	40.03
Yellowstone County	7.73	19.32	14.90	20.33	13.75	47.94
Chouteau County	14.18	17.35	13.29	11.95	28.90	34.56
Average	13.52	18.76	14.79	20.37	26.01	43.38

The percentage of rainfall retained will vary from season to season, and depends: (1) On the rate of rainfall during a given storm, (2) on the condition of the soil, (3) on the treatment of the soil following the rain, and (4) on the amount of humus or decayed organic matter in the soil. In a heavy storm the percentage of water escaping as "run-off" is very high, while the same is true on a hard uncultivated surface or one on which the surface mulch has not been restored since the last rain. Showers that do not penetrate beneath the surface mulch are soon taken up again by the sun and winds, but serve to reestablish the hard surface which draws moisture from beneath. So these light showers are a damage except in case of crops nearly ripe or undergoing a period of drought. In case of drought their chief advantage is to check the evaporation from the leaves of the plants rather than to feed the thirsting plant through its leaves, as is sometimes believed. To increase the ability of the soil to hold moisture, thin top-dressing of strong manure chopped or cut into the soil by means of a disk is recommended.

Summer tillage is especially recommended for fall-sown crops rather than those which would require the land to lie bare to the winds through the winter. It has yielded a profit in the case of oats, spring wheat, and barley. A short period of summer tillage is recommended for alfalfa to be sown in July or August as better than planting earlier on a land foul with weeds or drained of moisture by a previous crop. The most pronounced advantage of summer tillage has been realized with fall-sown wheat. In 1907 the North Platte Station in Nebraska obtained an average yield of 59 bushels per acre on 4½ acres of summer-tilled land, while an adjacent plat not summer tilled produced only 24.4 bushels per acre. Other land not under the control of the station averaged from 15 to 20 bushels per acre.

For summer tillage in western Nebraska, stubble land should be double-disked immediately after the removal of the grain crop to prevent the escape of moisture and growth of weeds. As soon as the frost is out of the ground the following spring it is again double-disked and the surface kept loose and free of weeds by the alternate use of the disk and tooth harrow until June, when the land is plowed 8 inches deep. This gives a deep mulch capable of receiving and retaining a large amount of rainfall. The surface mulch is then maintained without pulverizing the soil sufficiently to allow it to drift with the wind until the desired crop is to be sown.

A deeper mulch is required by "a fine, heavy soil," because it is more difficult to keep open than the sandy soil. The deep mulch is not so readily destroyed by light showers and therefore requires less frequent renewal. It is more efficient than the shallow mulch in keeping down weeds. A mulch 3 to 4 inches in depth can usually be maintained by the use of the spike-tooth harrow and the disk. It is usually sufficient to renew this mulch within a reasonable period after each rain, but during a prolonged drought it should be renewed more frequently.

Although the surface mulch is maintained it is of advantage to have the soil beneath sufficiently firm to draw water from the soil still lower, in order that it may be held at this point available for the roots of the plant without being allowed to escape to the air above. Subsurface packing also causes stubble straw or coarse manure to decay more rapidly by bringing them a greater amount of moisture. This subsurface packing is accomplished either by a special tool, known as a subsurface packer, or by a disk well weighted and run straighter than where the purpose is to stir the soil, thus enabling it to penetrate more deeply and pack the soil immediately below the surface. An extra horse may be hitched on the plowed side, thus rendering more firm the soil over which it walks, or reestablishing the surface mulch by dragging a section of harrow after it.

Since summer tillage has a tendency to exhaust the humus of the soil and so reduce its plant food and water-holding capacity, it should be resorted to only in connection with a rotation that will overcome these tendencies. A rotation recommended for localities where the crops thrive well is "summer till and sow winter wheat; disk and fall plow the wheat stubble for corn the next year; disk the corn stubble for a spring grain—oats, wheat, or barley; apply manure during the winter; disk in spring and plow for [sorghum] cane, which crop completes the rotation." Another means of restoring the humus content of the soil is by turning under green crops of rye and cowpeas or other green-manuring crops. This method has given almost the same advantages as summer tillage, at the same time enriching the soil by the addition of humus, but in very dry years trouble may be encountered through lack of sufficient water to rot the large amount of vegetable matter turned under.

The principles governing drought resistance in the crops or varieties best suited to dry-land agriculture are less perfectly understood than are those of the tillage problems involved. The drought-resistant plants generally have one or more of these properties: (1) The ability to root deeply and obtain water from the lower strata of the soil, (2) the ability to grow rapidly and mature during the season of greatest rainfall, (3) the ability to resume growth after withstanding a period of drought, or (4) in a more limited number of cases to prevent excessive evaporation by a small leaf surface or a glazed surface, as in the case of the cacti.

The crops that have given the best results in Montana are flax, brome grass, barley, wheat, potatoes, corn, and alfalfa. Thin seeding is quite generally recommended. Flax is best adapted for use as a first crop on spring-broken dry-land sod. It has shown an average yield of over 12 bushels per acre in all tests. Brome grass gives a higher yield than any other forage crop reported, giving a hardy growth and an abundance of good hay. Tall-oat grass is slightly below brome grass in yield. Alfalfa has as yet given very low results at these stations, but only one year's work has been reported. Kubanka, Ghirka, and Glyndon wheats seem well adapted to dry-farm conditions in this State and are freely used for bread-making purposes. Turkey Red fall wheat has given a higher yield than any other sort grown. A higher average yield has been obtained from fall-sown crops than from spring-grown crops. White Hull-less barley has been the earliest variety to reach maturity. Corn has yielded 4.44 tons per acre on one of the experimental farms of Montana, indicating its ability to yield forage under dry-farm conditions. An average yield of 124 bushels of potatoes per acre proved this crop a success on the farms of this State, but sugar beets failed to grow readily enough to make them a commercial success, although profitable to add succulence to the rations of the farm animals. Intertillage of crops has shown an absolute decrease on these farms of about 7 bushels per acre in the case of wheat.

The Wyoming Station has obtained good results with the same crops under its conditions and adds to these winter rye, spring rye, oats, spelt, sugar beets, and in the lower altitudes milo maize.

In western Nebraska good results have been obtained with winter wheat, spring wheat, oats, barley, emmer or spelt, corn, sorghum, Kafir, milo, brome grass, and in the valleys alfalfa has proved a most valuable forage crop, but its success on the table-land is more doubtful. Throughout these semiarid regions 3 to 5 pecks per acre have given better results in the case of small grains than seeding at higher rates. The work of the Office of Forage Crop Investigations has shown good results from the use of Siberian millet sown in the fall on summer-fallowed land, of barley used in the spring as a catch crop, and of the various sorghums experimented with. The Sumac sorghum has proved the sweetest and heaviest yielding variety as far north as the Kansas-Nebraska line. North of this point Red Amber sorghum matures earlier and produces a heavier tonnage of better feed than is secured by the growth of millet. The Kafirs produce more seed and less sugar than the Sumac sorghum and are adapted to the same region. They have the ability of suspending growth when the moisture supply is shut off and resuming it when the drought is over.

Cowpeas have succeeded well in the eastern portion of the dry-farming region when cultivated in rows 3 feet apart. They are less drought resistant but also less subject to the attacks of rabbits than are soy beans. The Bonavist (*Dolichos lablab*) is still more drought resistant, as is also the Kulthi (*D. biflorus*). The latter is the best legume for hay production experimented with at Chillicothe, Tex. The moth bean (*Phaseolus aconitifolius*) is successful but less valuable than Kulthi. Alfalfa requires at least 15 inches of rain in the Dakotas or 24 inches in Texas for successful growth when broadcasted. If cultivated in rows it may be made to produce profitable crops of seed with still less rainfall. Melilot or sweet clover is a good soil improver and of value for forage on sandy or moderately alkaline soils.

As pointed out in previous articles on this subject, too much emphasis can not be laid on the importance of supplementing dry farming with at least enough irrigated farming to insure garden products and forage for stock as a protection against possible failure on the dry land, because whatever the methods adopted, there are likely to be seasons when total or partial failure will be inevitable. The meteorological records of the dry regions as a rule show that wet and dry years occur in cycles and that seasons of excessive drought occur when, except by means of irrigation, little or nothing in the way of cultivated crops can be grown.

The Office of Experiment Stations of this Department has been investigating for several years the possibility and best methods of irrigating small areas in dry regions in connection with the farming of larger areas without irrigation. It has been found that although the greater part of the land lying between the one hundredth meridian on the east and the Rocky Mountains on the west is beyond the reach of canals from the streams of that section, and the water supply is not sufficient to irrigate any considerable part of it, by means of wells with pumps and tanks; small storage reservoirs to catch storm waters coming down coulees, draws, and small stream beds; intercepting ditches across broad slopes directing the run-off to the orchards or fields below; and the use of the soil and subsoil to store the storm waters of spring freshets, a sufficient amount of water may generally be provided to carry at least a portion of the crops over a period of excessive drought and thus make the difference between partial success and total failure.

METHODS OF SEEDING OATS.[a]

For the period 1903–1907 Iowa produced an average annual yield of 123,422,880 bushels of spring oats on 4,144,463 acres, or an average of 29.5 bushels per acre, valued at about 29 cents per bushel. Figures presented for Illinois show an annual yield of 112,200,000 bushels from 3,400,000 acres, averaging 33 bushels per acre and bringing 32.2 cents per bushel on the market, or a total of $10.63 per acre. Of this return $5.45 is consumed in the items of cost, sowing with a broadcast seeder, seed, disking once, harrowing twice, harvesting including twine, shocking, threshing, and marketing, leaving a gross profit of $5.18 per acre. This is insufficient to pay taxes and 5 per cent interest on $100 land. If cost of maintaining soil fertility, wear of machinery, and of additional labor involved, be considered, this gross profit is reduced to $3.33, or enough to pay taxes and 5 per cent interest on $60 land. At the present average yield, oats are profitable only because required in rotations or as a nurse crop. A large percentage of corn-belt farms can average 75 bushels per acre, in which case a profit of more than 20 cents per bushel, or $15 per acre, would result, and the oat crop would be profitable aside from its value in rotations. Among the more obvious and practical means of raising the present average are: (1) Improved methods of seeding, and (2) treatment for the prevention of smut preliminary to seeding.

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[a] Compiled from Illinois Sta. Bul. 136; Iowa Sta. Bul. 96; Kansas Sta. Bul. 74.

Loss due to smut is usually overlooked: (1) Because largely concealed by the shortness of the smutted stalks as compared with the healthy ones; (2) by the fact that many of the smutted heads do not push out of the sheaf leaves and so pass unobserved, and (3) because the smut has usually ripened and scattered its spores to infect the soil and neighboring healthy oats for the ensuing year before the normal plants have ripened their grain. The loss due to this cause in Illinois has been found to vary from one-fourth of a bushel to 13.25 bushels per acre, with an average amount of smut in oat fields of over 13 per cent. This loss can be almost entirely prevented by treating the seed with formalin at a cost of about 2 cents per bushel. Tests have shown that where 93 per cent of the plats sown with untreated seed produced oats with from 1 to 20 per cent of smutted heads, only 44 per cent of the plats sown with treated seed were infected with smut at all, while no treated plat had more than 1.2 per cent of smut. The formalin and other methods of preventing grain smuts have already been fully described in the publications of this Department.[a]

Of 452 Iowa farmers replying to circular letters, 96.6 per cent were found to plant oats on stalk ground, only 3.5 per cent raked and burned stalks, while 71.7 per cent did not break, harrow, or burn stalks, 70 per cent disked after sowing, 13.3 per cent before sowing, and 16.7 per cent both before and after sowing, 97.5 per cent harrowed after sowing, 11 per cent before sowing, and 9.2 per cent both before and after sowing. A seed bed more than 3.5 inches deep is not necessary for the oat crop because it is a surface feeder and responds quickly to a firm seed bed.

At the Kansas Station the average results from the eight years' trial of spring and fall plowings were almost equally good. Of successive sowings, about March 2, 9, 16, etc., until May 3, made with the press shoe drill at the rate of 3 bushels per acre, that of March 9 gave the highest average yield for the years when it produced a crop, but on one occasion it was lost by freezing. Sowings made April 20 and 27 were total failures one season. Seed from which the light oats had been fanned out produced an average yield during an eight-year test of 1 bushel more per acre than did similar seed not fanned, and nearly 3½ bushels more than did the light seed fanned out. The heavy seed produced more stalks. The highest yield per acre resulted from a seeding of 4 bushels, while Canadian experiments have obtained the highest yields from a seeding of 3½ bushels in one instance[b] and of 2½ bushels in another.[c] Surface-plowed land produced about three-fifths of a bushel more per acre than land subsoiled for corn the season prior to that in which it was sown to oats. Where a liberal coat of manure had been plowed under in the fall, both land packed once with a subsurface packer and that packed four times produced approximately 4 bushels more than the unpacked land. Under the same conditions, on spring-plowed land a still greater increase of yield was secured by the use of the packer. The land packed once showed an increased yield of more than 4½ bushels and that packed three times showed an increase of 7 bushels, as compared with the yield on the unpacked land. During this test the supply of moisture was abundant. Presumably a still greater benefit would have arisen from the packer in a dry or unfavorable season, as its object is to compact the soil, so retaining the moisture and supplying it more readily to the seed. At Lacombe, Canada, oats on packed soil yielded over 85 bushels per acre, while those on unpacked soil yielded 66 bushels and 30 pounds.[a]

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[a] U. S. Dept. Agr., Farmers' Buls. 225, p. 12; 250, pp. 8, 9, 13–15.

[b] Canada Expt. Farms Rpts. 1908, p. 347.

[c] Canada Expt. Farms Rpts. 1908, p. 385.

Perhaps the most practical seeding method of increasing the yield of oats is the use of the drill instead of the broadcast seeder. At Urbana, Ill., in 1905 the average difference in yield between oats planted with the drill and those planted with the broadcast seeder was 12 bushels, and on each of the 18 plats it was in favor of the drilled portion. In 1907 the difference was in favor of the drilled oats in 11 cases, in favor of the broadcast oats in 5 instances, while on the remaining 2 the yields were exactly equal. In 1908 the drilled oats were planted at the rate of 2 bushels per acre and the broadcast sowing made at the rate of 3 bushels. Out of 30 sowings made, 18 yields favored drilling, while 9 favored broadcasting, and in 3 cases the yields from the two methods were exactly equal. The average yield from drilling was 1.6 bushels greater than that from broadcasting, which, together with the saving in seed, gives this method an advantage of 2.6 bushels. It is seen that the weather conditions during the growing season make a great difference as to the relative yields obtained by these methods. Similar tests at De Kalb showed a net average of 2.7 bushels in favor of drilling as compared with broadcasting. The most marked difference at this station was shown on timothy sod, where 4 bushels per acre represented the advantage of the drilled oats over those sown by broadcasting. For two years at another point, land previously in corn, seeded to clover at the last cultivation of the corn, and planted to oats in 1906, showed an average difference in yield of 3.6 bushels per acre in favor of the drilled fields.

It has been found that plowing does not take the place of drilling, but that the advantage of drilling over broadcasting is even more marked upon plowed land than upon land disked before seeding. Plowing the land produced an increased yield of 2 bushels per acre, which was insufficient to pay for the difference between the labor of plowing and that of disking. In some instances the impossibility of harrowing in the oats immediately after they are broadcasted emphasizes the advantage of the drill, which both plants and covers at the same operation. The 3 Illinois fields quoted are representative of widely differing conditions, and show an average difference in yield of 3.9 bushels per acre, indicating the possibility of increasing the production of oats in this State alone by over 13,000,000 bushels annually, without any increase in acreage or improvement in other particulars. At the market price of 32.2 cents per bushel, this would mean an increased income of more than $4,000,000 to the oat producers. The increase in yield on 35 acres, it has been estimated, will pay for a drill in a single year. The difference in cost of sowing is almost nothing, as the experience of careful farmers indicates that the time and labor required to drill land is practically equal to that required in harrowing it once and going over it with a broadcast seeder. "This would certainly represent the minimum of work that could be done in each case. If, besides this, the broadcast land needs to be disked, while the disk-drilled land needs only to be harrowed, the drilled land would require less expense." A drill properly cared for "should not cost over $2.50 to $5 per year, depending upon size of drill and amount of land sown. * * * The question will likely arise as to what kind of drill to use. To this it is only necessary to reply that the only practical kind for corn-belt farmers is some good make of disk drill. The disk drill is the only kind we know that will not clog in going through an ordinary amount of cornstalks or other refuse on land. A good disk drill will do this without much trouble. Perhaps the disks should be 8 inches apart rather than closer together for this mechanical reason."

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[a] Canada Expt. Farms Rpts. 1908, p. 348.

A three years' comparison of drilling and broadcasting oats by hand at the Ontario Experiment Station Farm at Guelph, Canada, showed an average difference in yield of 4 bushels in favor of drilling during the three years of the test. At the Iowa Station, oats planted by the disk drill yielded 44.9 bushels of oats, weighing 23.5 pounds per bushel, while those broadcasted yielded 35.3 bushels, weighing 21.5 pounds per bushel.

The reason for the increased yield resulting from drilling oats is shown by careful study of the young plants. It is observed that they are planted at a more uniform depth, that none are left on the surface of the soil exposed to the drying of sun and winds or the action of freezing weather, that the soil is more closely pressed about them, and that germination is more prompt and uniform, and that the patchy appearance somewhat common to oats sown by hand or otherwise broadcasted is overcome. When the rows of oats run north and south, young clover receives more sunlight, and is better able to endure the hot sun when the oats are harvested. The comparison of the use of the disk drill and the broadcast seeder in planting oats shows these advantages for the drill: (1) Increased yield per acre, (2) economy of seed, (3) uniformity of stand, (4) a greater uniformity in regularity of growth and time of heading and ripening, (5) less harmful influence on young clover when the oat crop is removed, and (6) equal or greater economy in cost of labor in seeding.

ROLLING VERSUS HARROWING WINTER WHEAT.[a]

The Nebraska Experiment Station has been carrying on for several years (1902–1906) at Lincoln comparative tests of harrowing and rolling winter wheat, an account of which is given by E. G. Montgomery in a recent bulletin of the station. Plats were seeded to Turkish Red winter wheat, some sown broadcast, others put in with a press drill. Some of the plats were harrowed in both fall and spring, others were harrowed only in the spring, while a third set was rolled.

It was quite evident from the results that no benefit was derived from the harrowing. In fact "harrowing broadcasted wheat resulted in an average loss of almost 3 bushels per acre, while harrowing drilled wheat resulted in a loss of nine-tenths of a bushel per acre."

It is suggested, however, that the harrowing, on account of its influence in conserving moisture, might be beneficial in drier regions or seasons. As a whole there was no lack of moisture during the years in which these experiments were made, but "in the two seasons when spring rainfall was below normal (1905 and 1906) there was some increase from cultivation."

The results from rolling were conclusive. In no year did it fail "to give an increased yield, the average increase being 5.1 bushels per acre."

> The rolling was given early in the spring, soon after frost was out, and about the time growth started. Harrowing after rolling was not as good as rolling alone, probably due to loosening up the plants again after the roller had pressed them firmly into the soil.
>
> Early spring rolling of winter grain, pressing the earth as it does firmly about the plant roots, produces good results. When frost comes out in the spring it is very apt to leave the soil filled with small cracks or checks, especially around the plants [fig. 2]. If these checks are examined closely, it will be seen that a large number of roots are thus exposed, and if the weather continues dry they are killed or at least injured. * * *
>
> If the soil is not wet at the time of rolling—and it should never be rolled when wet—rolling aids in no small degree to form a surface mulch.

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[a] Compiled from Nebraska Sta. Press Bul. 30.

The Nebraska Station experiments, therefore, point quite clearly to the conclusion that under ordinary conditions of normal seasons in humid regions winter wheat is sufficiently benefited by rolling to make the practice profitable, while harrowing is not to be recommended under such conditions.

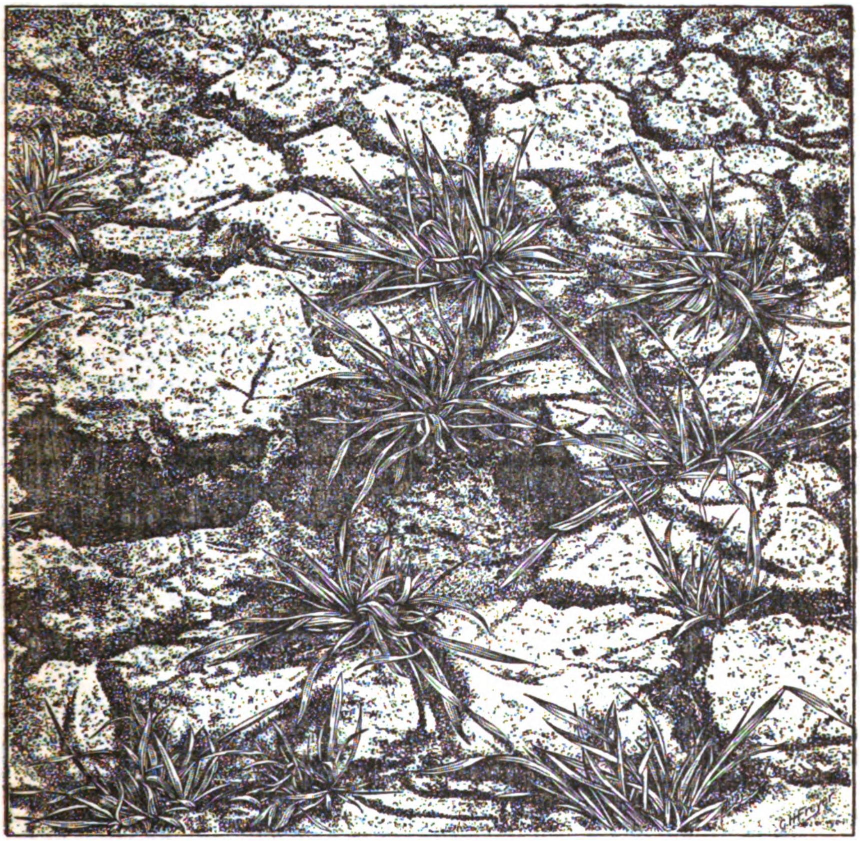

FIG. 2.—Appearance of the surface soil of a wheat field in spring.

DESTRUCTION OF EELWORMS IN GARDEN AND GREENHOUSE SOIL.[a]

Eelworms or nematodes in garden and greenhouse soil constitute a serious and troublesome pest for which it is extremely desirable to find some simple and practical remedy. Experiments on various methods of destroying eelworms have been carried on for many years by G. E. Stone, of the Massachusetts Experiment Station, and a recent report of that station gives some of the practical results of these experiments.

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[a] Compiled from Massachusetts Sta. Rpt. 1908, pt. 1, pp. 56–61. See also U. S. Dept. Agr., Farmers' Buls. 186, p. 8; 259, p. 9.

As Doctor Stone points out, the use of lime is often advocated for destroying the eelworms, but his experiments show that lime has little or no value for this purpose. In fact, it was found possible to keep eelworms alive for several days in a saturated solution of limewater. "Undoubtedly the application of lime to greenhouse soil improves it by modifying its acidity, but eelworms will thrive in soils which are not acid."

The use of formalin has been recommended, but the experiments at the Massachusetts Station indicate that this is not effective in killing the worms, and besides can not be used on soils containing growing plants on account of the injury likely to result to the plants.

Of late years formalin has been recommended as a remedy for eelworms on violets. This is used by applying it to holes made in the soil where the plants are growing. The formalin being volatile, the gas penetrates the soil and is said to kill the worms. Our experiments with it would not seem to warrant the use of this method of treatment, as formalin is injurious to plants, and there is reason to believe that it would not affect in the least the eggs of eelworms, which are fairly well protected by a resistant covering.

The methods used with more or less success at the Massachusetts Station for destroying eelworms in greenhouse soils were as follows:

Sterilization.—This is one of the cheapest and best methods of destroying eelworms in greenhouse soil. It is necessary that the soil be heated to at least 180° F., and a higher temperature is better. This is accomplished by driving steam through the soil by a system of perforated pipes.

Freezing.—If the soil is frozen for any length of time the eelworms are destroyed, and some use has been made of this method by practical growers. As a rule, the soil is removed from the house and frozen in bulk out of doors.

Desiccation.—Drying the soil is destructive to eelworms, but it is difficult to dry soils sufficiently in deep benches to make this method effectual. The application of unslaked lime, however, will materially aid in drying the soil, by virtue of the water-absorbing qualities of the lime. * * *

Trapping, or the catch-crop method.—It has been found in Germany that sowing very susceptible crops, like mustard or rape, on soil contaminated with eelworms, and, after the females have become encysted in the roots, pulling up the plants and exposing them to the drying rays of the sun, is capable of reducing the worms to some extent in contaminated soils. We have found, however, that two or three catch crops are much better than one.

The Massachusetts experiments indicate that in some instances simply flooding the soil may prove a successful means of destroying the eelworms, and that manure infected with eelworms may be safely used on garden and greenhouse crops if left for a sufficient length of time in water.

PRUNING.[a]

As the season approaches when pruning must be done, if attempted at all, it may be worth while to consider briefly the importance and advantages of this practice. These are strongly set forth by O. B. Whipple in a recent bulletin of the Colorado Experiment Station, as follows:

Many and varied are the excuses offered by the man who owns an unpruned orchard; he is ashamed of the neglected trees and tries to justify himself by advancing what he considers, or more likely what he tries to persuade himself, is a good reason. One holds that pruning is little short of sacrilege, contrary to the laws of nature; another tells of his fond recollections of childhood and what excellent fruits he picked from the old apple tree, pruned alone by nature; another says it does not pay, and in his particular case it does not, for the chances are that the orchard is neglected otherwise. The only excuse that has any semblance of justification is that of ignorance, and that does not excuse the man who makes no attempt. Nature's object is the production of seed with provision for its distribution, and she is satisfied when a cherry is produced with enough flesh to attract some fruit-loving bird that may, perchance, drop the seed far from the parent tree. Man grows the fruit for its fleshy parts and tries to improve these parts as much by placing the plant in a more favorable environment as by plant breeding and selection. * * * The man who can not afford to prune can not afford to grow fruit, and the man who does not know how to prune must learn; the principles are not complicated.

The general principles which should guide in intelligent pruning are concisely stated by Professor Whipple, as follows:

Physiology of pruning.—To be an intelligent pruner one must know something of plant physiology. He should know the effects produced by pruning at different seasons of the year, how to make a cut that will heal most readily, and the influence of pruning on the fruit-bearing habit of the tree. * * * It is generally conceded that pruning during the dormant season incites wood growth, while pruning during the growing season promotes fruitfulness. * * *

Although it is said that pruning during the summer season may encourage the formation of fruit buds on tardy-bearing varieties, it may have the opposite effect, unless done at the proper time, and may cause late growth and unfruitfulness. To give the desired results one must summer-prune shortly before the season of growth ends; earlier pruning starts new growth, while late pruning gives no results. The benefit derived from summer pruning seems to depend upon the ability of the pruner to prune at a time to bring about early maturity. In an irrigated section, where soil conditions are easily controlled, the same end may, no doubt, be more easily attained by proper manipulation of the irrigation water.

Both the season at which the wound is made and the character of the cut have an influence upon the healing process. The pruner should remember that all food material capable of healing a wound is taking a downward course through the inner bark, and that to heal well a wound must be in a position to intercept the downward flow of sap from foliage higher up. When a limb is to be removed entirely, the cut should be at the union with and parallel to the surface from which the limb arises. Where limbs are to be headed back, they should be cut to a side limb and not to a bare stub. Wounds naturally heal best when made at a season of the year when growth is most active, but with the possible exception of wounds made in early winter and subjected to a long season of drying, the season at which the wound is made has no important bearing upon the healing process. The grower who has a small orchard that will permit of such a practice should delay the pruning until as near the opening of the growing season as possible.

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[a] Compiled from Colorado Sta. Bul. 139.

The influence of pruning upon the fruit-bearing habit of the tree has been briefly mentioned, but * * * a fruit-bearing habit may, to a certain extent, dictate a course in pruning. The fruits with which this discussion has to deal have two general types of fruit bearing—from terminal fruit buds and from axillary fruit buds. The first type of fruit bud is well represented in the apple and pear, and the latter in the stone fruits. Trees which produce axillary fruit buds are naturally more prolific and require severe pruning as a means of thinning the fruit. In fact, a system of pruning under which the tree with axillary fruit buds would thrive would cause the apple tree to overgrow to such an extent that it would be rendered almost barren. The point may be more fully illustrated by comparing the peach and the cherry. Although both develop axillary fruit buds, they differ in their fruiting habits; the fruit buds of the cherry are seldom found on the stronger growing new wood, and severe pruning, as practiced on the peach, would throw much of the strength of the tree into the production of strong wood that would carry very few fruit buds. We have said that in the apple the type of fruit bearing is from terminal buds, yet many varieties develop axillary fruit buds. Varieties which develop axillary fruit buds and bear terminal fruit buds on young spurs all tend to overbear, and require severe pruning. So to a certain extent one can decide for himself how much to prune by observing how the tree bears its fruit.

Treatment of wounds.—The argument in favor of dressing wounds is that it prevents decay and checks evaporation, both of which might interfere with the healing process. While in our arid climate the first is hardly applicable, the second should probably be doubly important. Yet, the matter of dressing wounds is not so important but that work improperly done is worse than no treatment. A good lead paint is one of the most satisfactory dressings yet found. Rather a thick paint should be used, and careless daubing of the surrounding bark should be avoided. Grafting wax is a good dressing, but is rather expensive and difficult to apply. Other materials have been used, some successfully and some disastrously, and the grower is to be cautioned about experimenting; better stick to materials known to be safe and efficient. Growers often overdo the matter and waste time treating small wounds. Surely a wound less than 1½ inches in diameter is not worth bothering with.

These suggestions apply to wounds made by the careless cultivator, as well as those made by the pruner. Unsightly wounds and permanent injury may often be avoided by proper treatment of trunk wounds. When the body of the tree is injured, the ragged edges of the bark should be pared off to sound tissue and the whole injury covered with paint or grafting wax. If promptly done, this prevents drying out of the tissues, and new bark will readily form, except on parts where the outer wood cells are actually destroyed, and in time this will grow over. Wrapping the injury with cloth, or if it is near the ground mounding earth up over it will often answer the same purpose.

Pruning tools.—Every pruner should be furnished with good tools; good tools encourage him to do good work. This does not necessarily mean that he must have every tool on the market. Many of them are useless. It does mean, however, that the ax and a dull saw have no place in the catalogue of pruning tools. The pruner needs a good saw, a good pair of light shears, a pair of heavy shears, possibly a good heavy knife, and, of course, a good ladder. Two common types of saws are found on the market. The common saw with teeth on both edges is a good, cheap one and will answer the purpose in many cases. The various makes of the swivel saws are much handier, however. The blade is stretched between swivels and can be turned to any angle with reference to the frame. It is well adapted to close work in the crotches of the tree. This type of saw can generally be bought for $3. The blades are not so frail as they look and seldom break, if properly handled. They can be replaced at a cost of 50 cents. It is really the best type of pruning saw and should be more universally used.

A good type of hand shears is indispensable for light work. Various makes are on the market; buy the one that appeals to you. A pair of heavy shears is almost as essential; they take the place of the saw in many cases and will do the work in less time. They are used in heading in limbs where the saw can hardly be used; the peach pruner finds good use for them. They work well on limbs up to 1½ inches in diameter. The only objection the writer has to this tool is that the pruner sometimes gets careless and leaves stubs. There is a type of heavy shears on the market that has two cutting edges instead of one, but it seems to do no better work. The pruner finds very little use for a knife in pruning mature trees and seldom carries a special pruning knife. Several types of the long-handled tree pruners are on the market, but they are of little value in the orchard. The pruner should be close to his work, and with a good ladder and short-handled tools he will do better work.

The principles and practice of pruning are discussed in detail in a Farmers' Bulletin of this Department,[a] prepared by L. C. Corbett, and the reader is referred to that bulletin for practical directions regarding the pruning of fruits, ornamental plants, and street and timber trees.

BEAN ANTHRACNOSE OR POD SPOT.[b]

Nearly everyone is familiar with the spotted appearance of snap beans, especially of the wax-podded varieties. This all too common disease has been known for many years and a good description has been given of it by Beach[c] and Halsted.[d]

The disease, which is of fungus origin, goes under a number of names, as rust, wilt, pod spot, etc. As there is a true rust and a wilt, caused by bacteria, the name pod spot or anthracnose is preferred for it.

Practically all parts of the bean plant except the roots are subject to attack of the fungus. The most common indication of the presence of the disease is the occurrence of brown or black sunken areas on the stems, leaves, and pods. They may also appear on the seed leaves (cotyledons) and stems of the plant soon after it appears above ground and cause considerable losses through a reduction in the stand. On the older plants the attack is most serious on the larger veins of the leaves, and the leaf may be wholly destroyed or its efficiency greatly reduced (fig. 3). From the stems and leaves the fungus spreads to the pods, and as many are rendered unsightly considerable direct loss is occasioned (fig. 4).

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[a] U. S. Dept. Agr., Farmers' Bul. 181.

[b] Compiled from Louisiana Sta. Bul. 116; New York Cornell Sta. Buls. 239, 255; Insect Pest and Plant Disease Bur. Nebr., Div. Bot. Circ. 6.

[c] New York State Sta. Bul. 48.

[d] New Jersey Stas. Bul. 151.

The presence of the fungus is often unnoticed until it appears upon the young pods. On these it produces small brown or rusty spots, which enlarge and darken until they become nearly black. The affected tissues of the pod dry, leaving sunken areas, in the centers of which may be seen small pink spots, masses of spores which rapidly spread the disease from plant to plant. The fungus grows by sending fine thread-like filaments into the cells of the bean plant. When on the pods, these filaments often reach the beans within the pod, and unless they are entirely destroyed the dried beans become a means whereby the disease is carried from crop to crop. This is now believed to be the principal means by which the fungus passes the winter, and this offers an important clew as to means for preventing the disease. Diseased beans may be recognized by the brownish or yellowish discoloration of the seed coats, and when badly affected the seeds will be more or less shriveled in addition to being discolored. When such seed are planted the dormant fungus resumes its growth with that of the plant and the seedlings are soon affected. Some efficient method of seed treatment should reduce the amount of disease, but none is known as yet. Careful hand selection, in which all discolored, shriveled seed are rejected, will reduce the amount of the disease somewhat, but it has not proved a wholly satisfactory method. A better method is selection of seed while still in the pods.

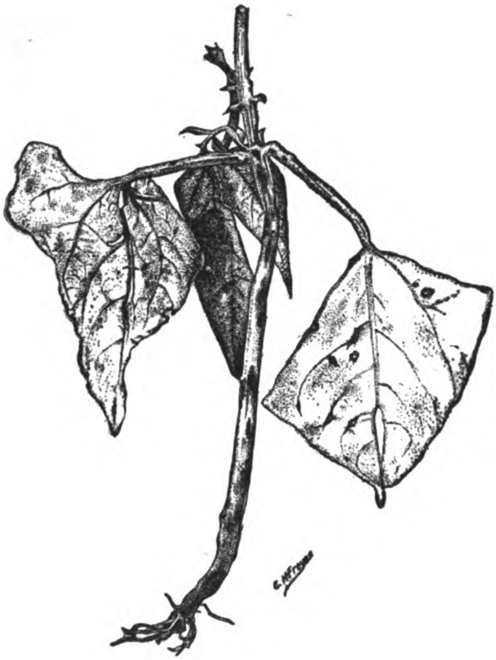

FIG. 2.—Anthracnose spots on stem and leaves of the bean just before blossoming time.

If no spots are to be seen on the pods, the seed will be reasonably free from the fungus and sound seed when planted will give a clean crop. On this account, extra efforts should be made to secure good seed. It has been suggested that seed be grown in uninfested regions, but dealers can not always be sure of the absence of the fungus from any particular region, the disease having spread to most of the important bean-growing regions.

For the average gardener selection of seed from the growing crop, all spotted pods to be rejected, and care in planting, so as to be away from other areas of beans, will give a clean crop, if a few ordinary precautions are observed. The spores by which the fungus is spread from plant to plant are very sticky when wet and are readily transferred on the hands, clothing, or implements. On this account beans should never be cultivated or gathered while wet with dew or rain. If it is too much trouble to observe these precautions for the whole crop, it could be done with little extra effort for a small plat on which to grow seed for future planting. There is some prejudice in certain quarters against the raising of seed at home, but experiments at the Louisiana Station gave as good results with home-grown bean seed as with that introduced from a distance.

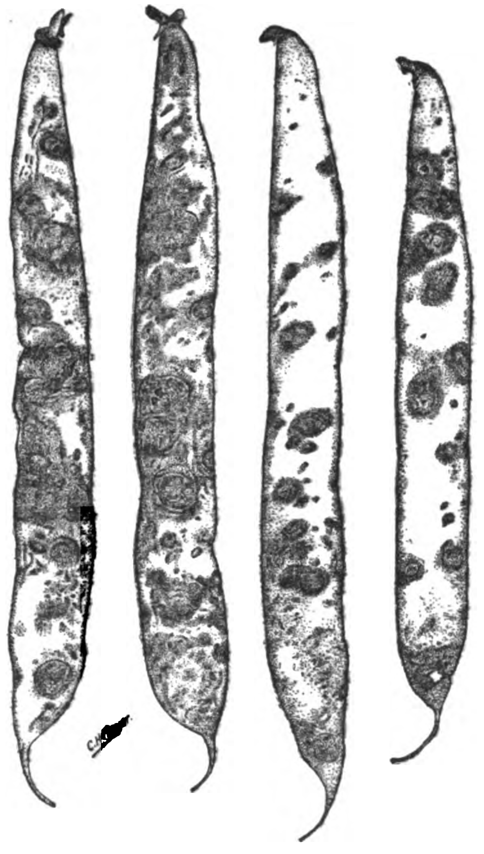

FIG. 4.—Anthracnose spots or cankers on bean pods.

Formerly spraying with Bordeaux mixture or other fungicides was recommended for the control of the pod spot, and if very thoroughly done at frequent intervals it may prove efficient, but in the light of present experience, if the following recommendations are observed, but little loss will result from anthracnose or pod spot:

(1) Plant seed free from disease.

(2) Keep away from the plants while they are wet.

(3) Remove and burn diseased plants as soon as they are observed.

ANIMAL FEEDS FOR FARM STOCK.[a]

The use of various by-products of the meat industry as stock foods has rapidly increased in recent years. As a rule these materials are rich in nutritive matter, very digestible, and furnish an excellent source of protein for farm stock of various kinds. In a report of the Massachusetts Experiment Station J. B. Lindsey says:

> In the United States up to the present time the various residues from slaughter-houses and fish factories have been utilized chiefly as sources of plant food. Of late the large packers have endeavored to popularize such material in place of or as a supplement to protein concentrates of vegetable origin. Large amounts of meat scraps and meals are consumed in the rapidly increasing poultry industry, and several brands of specially prepared or digester tankage and dried blood are recommended and offered for sale, although not generally distributed in local markets.

The value of meat scrap and tankage as feed for pigs and poultry has been discussed in previous bulletins of this series.[b]

At the Massachusetts Station tankage was fed to dairy cows in a mixed grain ration at rates of one-half pound daily, gradually increasing to 1½ pounds. The animals ate the tankage readily when mixed with grains, in spite of its noticeable odor. "Frequent samples of milk were examined, both cold and at a lukewarm temperature, but it was not possible to detect any flavor or odor that could be attributed to the meat product. It is hardly considered advisable, however, to feed such material to dairy stock."

The use of dried blood has not been so fully studied as that of tankage. References to its use as feed for pigs, calves, horses and mules, and poultry have been made in previous bulletins of this series.[c] Doctor Lindsey states that—

> Dried blood for feeding purposes is prepared by heating the fresh blood of cattle and swine in large tanks at 212° F. The excess of water is removed from the coagulated mass by means of heavy presses and the material then passed through steam driers and eventually ground and bagged. As thus treated it appears as a dry, friable powder of dark color and with only a slight odor.

Experiments at the Missouri and Wisconsin experiment stations, in which dried blood was fed with corn to hogs, showed that "the addition of the blood produced a more rapid and healthy development of the body and tended to increase the proportion of lean meat."

Digestion experiments with sheep and tests of the feeding value (as compared with cotton-seed meal) for dairy cows of a sample of blood meal containing 84.64 per cent of protein, 3.18 per cent of ash, and 0.37 per cent of fat were made at the Massachusetts Experiment Station. The results were in brief as follows:

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[a] Compiled from Massachusetts Sta. Rpt. 1908, pt. 2, pp. 149–157.

[b] U. S. Dept. Agr., Farmers' Buls. 169, p. 29; 276, p. 21.

[c] U. S. Dept. Agr., Farmers' Buls. 169, p. 30; 186, p. 26; 222, p. 19; 233, p. 25.

(1) Dried blood contains some 85 per cent of protein, and when properly prepared (not overheated) has proved itself to be highly digestible and well suited as a concentrated protein nutrient for farm stock.

(2) For cows in milk it may be fed in amounts varying from 1 to 2 pounds daily, mixed with concentrates of vegetable origin. A satisfactory combination for a day's ration consists of 2 to 3 pounds of wheat bran, 2 to 3 pounds of corn or hominy meal, and 1.5 pounds of dried blood. Other mixtures can be made containing blood as a constituent.

(3) It is believed to be the part of economy to first utilize blood as an animal food rather than to apply it directly as a fertilizer.

(4) The present price of prepared blood, its lack of distribution in local markets, and the ignorance of the consumer concerning its merits as a food have thus far prevented its general use for feeding purposes.

The dried-blood ration was about 2 per cent more expensive for milk production and 5 per cent more expensive for butter production than the cotton-seed meal ration, the cost per 100 pounds of milk being with the blood ration $1.04 and with the cotton-seed meal ration $1.02, the cost per pound of butter 17.7 cents with the blood ration, and 16.9 cents with the cotton-seed meal ration.

FEEDING THE PIG.[a]

This is the title of an interesting and instructive circular of the Illinois Station giving the results and conclusions from several years' experiments by W. Dietrich. The experiments were begun in 1904 with the purpose of developing a new feeding standard for swine, "or to put the practice of swine feeding upon a fundamental basis and into such form that anybody who can follow instructions may get large and economical gains." By the method of feeding developed as a result of these experiments 40 per cent greater gain in live weight was produced than when the old feeding standards were followed. In the methods proposed particular importance is attached to exercise, to the control of the water consumed, and to supplementing the mineral matter and fat found in ordinary feeds.

A fact that has recently been determined indicates that the influence of exercise upon the functional activities of a pig is an important factor. Hence the lack of exercise is a handicap to the fall pig because during the winter on account of cold weather not so much exercise is usually taken as in the summer, except during very hot periods. For maximum and most economical production it seems absolutely necessary for the young and growing pig to have an abundance of exercise. Its chief value seems to be in the influence it exerts upon the respiratory and digestive functions.

If pigs are changed from lots where they have had considerable exercise to lots where they do not have so much, their feed must be correspondingly reduced. Hence they will also make smaller and usually more expensive gains. If the weather conditions are such—as, for instance, when it is very cold—that the pig does not take the usual amount of exercise, the ration should also be reduced correspondingly.

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[a] Compiled from Illinois Sta. Circs. 126, 133.

The marked benefit derived from pasturage is attributed to the fact "that in grazing the pigs get the needed exercise which stimulates the functions of respiration, digestion, and metabolism, thus enabling them to utilize larger quantities of feed to better advantage. That is, they will make larger and more economical gains from a given quantity of feed, grain, and pasture combined when they have exercise than when they have no exercise."

In order to get best results it is undoubtedly necessary, as shown by the experimental data, to feed the right quantity of water as well as the right quantity of the other nutrients; and * * * another one of the principal reasons that winter feeding of pigs has not been more successful is because an insufficient amount of water was used. During the winter season in cold climates where the pig is given dry feed and free access to water he will apparently not drink enough for maximum and most economical production.

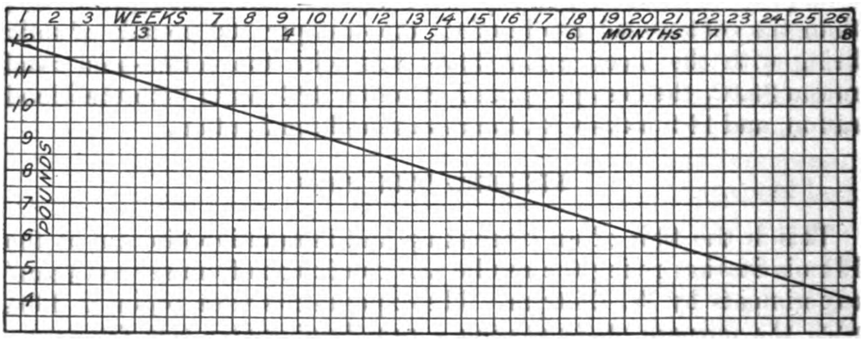

FIG. 5.—Diagram showing the water requirements of pigs at different stages of growth (from 2 to 8 months old).

As indicated in figure 5, the water requirement begins with 12 pounds daily per 100 pounds of live weight for pigs two months old and falls gradually to 4 pounds daily for pigs eight months old and in prime condition for market.

In general all the water is given with the feeds in the form of a slop, but a limited amount of recent data seem to show that, in so far as the water is considered in itself, it makes some difference as to how it is fed, as well as the use of the right quantity. The best results have been obtained by feeding the bulk of the water after the rest of the feed has been eaten, using enough water to wet the dry feeds and enough feed in the water to make it palatable. During the hottest weather, however, it seems to be necessary to add a little more water to the dry feed. But the manner in which water is used in a ration may exert considerable influence in other directions, as, for instance, the distribution of the other nutrients, the amount of exercise the pigs get, etc.

By giving the pigs dry feed or a thick slop and then free access to water they did not do as well as in cases where the above-specified quantity of water was mixed with all the dry feeds in the form of a slop. The former method, however, produced better results in summer than in winter, but was also comparatively ineffective during the hot weather. This, which is also borne out by the data when compared with the water curve, indicates that in winter the pig will not drink enough and that during the hot weather of summer he will drink too much when he is given free access to water.

[In view of the fact that] the amount of mineral matter present in the soil, in the water, in the vegetation, and in different feeds is so decidedly variable, and since there is no standard for the requirement of mineral nutrients by the pig, it seems necessary in order to get best results in feeding to give the pig free access to a variety of mineral substances, so that he can supply, according to the dictates of his appetite, whatever is deficient by way of mineral substances in his feed. In order to supply these mineral substances, the results on the station farm seem to be quite satisfactory if the pig is given free access to salt, charcoal, air-slaked lime, bone meal, wood ashes, clean soil, and soft-coal cinders. These, with the exception of the last two, are kept in different compartments of a trough before the pigs at all times.

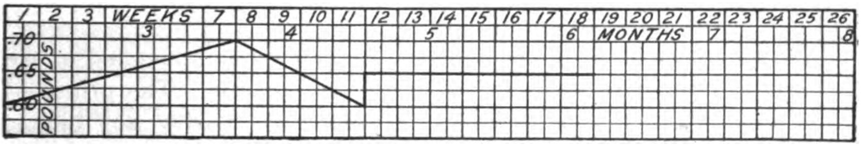

FIG. 6.—Diagram showing the crude protein requirements of pigs at different stages of growth.

Apparently, also, pigs "make larger gains if they are given a little more fat in their ration than is ordinarily present in the common feeds of the farm." It is somewhat difficult to control this factor, but it may in a measure be controlled by using in the ration feeds like soy beans which are rich in fat.

Figure 6 shows the amount of digestible crude protein required by the pig daily per 100 pounds live weight, according to the data determined, for maximum and most economical production. The curve starts at 0.6 pound at the beginning of the experiment and rises to 0.7 during the first seven weeks. Following this it declines to 0.6 during four weeks' time, then maintains a level of 0.65 for the next seven weeks. After this the greater part of the nitrogenous feeds are removed from the ration during four weeks' time. Some protein, however, is fed to the close, as pigs will do better if they have more protein than is found in corn. * * *

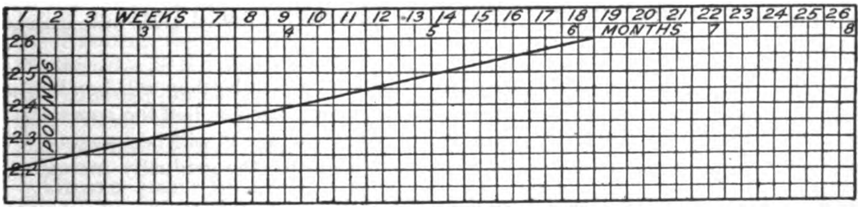

FIG. 7.—Diagram showing carbohydrate requirements of pigs at different stages of growth.

Figure 7 shows the amount of digestible carbohydrate required by the pig daily per 100 pounds live weight. It will be noticed that starting with the pig at two months of age he should have 2.2 pounds of digestible carbohydrate daily per 100 pounds live weight. After this, as indicated by the curve, it is gradually increased during the following eighteen weeks, when the curve reaches 2.6 pounds.

In the experiments at the Illinois Station "the pigs were usually started at two months of age and fed until they were eight months old, making a feeding period of twenty-six weeks. The carbohydrate curve, as above given, extends over only the first eighteen weeks of the experiment. During the last eight weeks the pigs were put on full feed on a ration that was primarily [carbohydrate] in nature." Later experimental data "seem to indicate that this curve might be raised to good advantage, starting at 2.4 and ending at 2.8 pounds."

The composition of feeds and the compounding of rations are explained in another Farmers' Bulletin of this Department,[a] and will not be discussed in detail here.

In order to get large and economical gains it is recommended to use as large a number of feeds in the ration as possible. The principal feeds used in the Illinois experiments were corn, barley, soy beans, skim milk, and alfalfa.

> [To secure uniform distribution of the nutrients of the feed] it is suggested that the grains used be ground and mixed with the milk and water, thus making a slop of all the ingredients except the mineral matter. A little of the corn, however, may be fed whole in order to develop the teeth and to accustom the pigs to feed in this form for purposes later in life when it may be advantageous to use feeds in this form.
>
> The feeding trough should be arranged, either by a swinging panel over the trough or by having it in a separate feeding pen, so that the slop can be poured into it without being disturbed by the pigs. When the slop is in the trough and the pigs are all present the panel over the trough may be swung back or the gate, which should be a wide one, may be opened into the feeding pen so that all the pigs can come to the trough at the same time. Then, by having pigs of equal size in the lot and not having too many together, there will result a good distribution of the nutrients to the different individuals of the lot.

In the Illinois experiments alfalfa was used as a rough food primarily to furnish bulk. Pigs two months old will not eat much of it.

> As they grow, however, during the next two or three months they will be able to take more, and the quantity in the ration should be increased so that the appetite of the pigs is nearly satisfied. After four or five months of age it will be necessary to gradually decrease the alfalfa in order to make room for the gradually increasing quantity of the protein and carbohydrate nutrients.

The alfalfa may be fed in the form of meal mixed with other feeds in the slop.

> But this is an expensive form in which to feed alfalfa. In the summer time pigs may be allowed to eat it from the pasture. In winter the alfalfa may be chopped as fine as possible with an ordinary fodder cutter and then mixed with a little meal and sufficient hot water or steam to thoroughly wet it. This will be eaten very readily if fed while the pigs are hungry. If bran is used as a roughage it may be mixed into the slop.

It is believed that the best results will be secured by feeding three times a day except perhaps when the pigs are getting considerable green feed from pasture. In that case the noon feed may be dispensed with.

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[a] U. S. Dept. Agr., Farmers' Bul. 22.

JELLY AND JELLY MAKING.[a]

In connection with studies with fruits J. Belling, of the Florida Experiment Station, reports the results of extended investigations of the character of guava juice and of the conditions which attend successful jelly making with this fruit. According to his results, a preliminary heating of the fruit is essential, as juice expressed from the raw fruit did not flow readily, and though it gave a light, amber-colored jelly with the proper proportion of sugar, with or without citric acid, yet the characteristic guava flavor was entirely lacking. The juice from heated fruit passes through the filtering cloth more readily than that from raw fruit, and the heating also seems to help in extracting the fruit flavor.

> The flavoring quality does not appear to reside in the oil glands of the rind * * *.
>
> In the boiling of guava jelly some acid (the natural acid of the ripe fruit) is absolutely necessary to change much of the sucrose into invert sugar, and if this does not take place then the sucrose [cane sugar] crystallizes out. Too much acid (and probably too prolonged boiling) seems to make the jelly sticky from the excess of invert sugar, and also to alter the pectin so that it will not gelatinize.
>
> The pink color of guava jelly does not seem to depend on any pink color in the flesh of the fruit, though the white guavas yield a lighter jelly. The depth of color seems to be increased by additional amount of acid, prolonged boiling, and higher temperature at which the boiling is stopped.

The following directions are suggested for making guava jelly:

> Cut the guavas in pieces with a sharp spoon (not iron) or with a plated knife. Heat them till quite soft in an enameled or aluminum vessel, with a small amount of water at the bottom, or in a double boiler without water. Put the soft fruit in a strong cloth bag, or folded in a cloth between boards, under a strong press. Measure the hot juice. Heat it in a deep clean pan (leaving room for the extensive frothing), adding a quantity of powdered white sugar equal in bulk to the undiluted juice. When the sugar has dissolved, the hot solution may be filtered through cloth. Boil down until the thermometer in the liquid marks the point which gives jelly of the color and consistency desired, which may be 113° C. (235° F.), or some neighboring temperature. Run the hot liquid into glass jars or into molds. Tough jelly which is not sticky may be satisfactorily packed in shallow ornamental boxes, as is done in Cuba.

Guava juice ferments quickly after it is expressed. According to Professor Belling, when it is desirable to keep the juice for jelly making—

> It may be put hot from the press into clean glass bottles or jars immersed to the neck in hot water, which is then kept above 140° F. for half an hour or so. The stoppers, corks, caps, or rubber rings should be heated in the same way and the bottles of juice closed when hot. Such sterilization of the acid juice will obviate the necessity for the addition of chemical preservatives.

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[a] Compiled from Florida Sta. Rpt. 1908, pp. 105–109; U. S. Dept. Agr., Office Expt. Stas. Ann. Rpt. 1907, p. 29; Jour. Home Econ., 1 (1909), No. 3, pp. 261–266; Jour. Indus. and Engin. Chem., 1 (1909), Nos. 6, pp. 333–340; 7, p. 436.

At the department of household administration of the University of Chicago Miss Jenny H. Snow studied the effects of sugar and temperature on fruit juices. It was found that "currants, grapes, and plums would jelly without adding sugar, but the product was neither clear nor palatable and the cost, in the case of the currants, was over a dollar a glass."

Jelly which contained the smaller proportion of sugar (one-half cupful to a cupful of juice) seemed to keep as well as that containing the larger proportion (one cupful of sugar to one of juice).

In the case of apples, the average density of jelly at the boiling point was not far from 30°. With plums it was on an average somewhat lower; with currants it varied from 24 to 28°, being about 27° on an average.

> The density at which a good product may be obtained varies with different fruits, but seems to be nearly uniform for each fruit and not affected by the amount of sugar used.
>
> This density was obtained at a lower temperature and in less time with the larger amount of sugar. The smaller the amount of sugar used the longer the period of boiling required and the darker the color of the product.
>
> In each case the smaller the amount of sugar the more pronounced the fruit flavor of the jelly.

Miss Snow also studied the effect of adding sugar to acid fruit before and after cooking. The belief is quite widespread among housekeepers that if sugar is added after fruit is cooked a smaller quantity is required for sweetening than is the case when it is added before cooking. Miss Snow also studied the relative sweetness of cane sugar (the ordinary sugar which is obtained from sugar cane, sugar beets, and the sugar maple) and invert sugar (dextrose and levulose), which are found in nature in fruits, etc., and which can be obtained from cane sugar by inversion, as, for instance, by cooking sugar with acid. According to her results, dextrose is much less sweet and levulose sweeter than cane sugar, while a mixture of equal parts of dextrose and levulose is sweeter than cane sugar.

When cane sugar was added to apples before cooking and boiled with them, it was found to be largely inverted. When added at the close of the cooking period, it was only slightly inverted, and, although the invert sugar is less sweet than cane sugar, yet "the difference in sweetness between stewed apples when the sugar has been added before and after cooking, respectively, is so slight as to be of little practical consequence * * *.

"The experiments, with one exception, show that the acidity is less in apples cooked in water, either with or without sugar, than in uncooked fruit."

An extended study of the chemistry and physics of jelly making, carried on by Miss N. E. Goldthwaite at the department of household science, University of Illinois, gave a number of results which are of general interest.

Miss Goldthwaite states that—

> The essential constituents of a jelly-making fruit juice are: First, pectin [a carbohydrate body closely related to starch and a very common constituent of fruit and some vegetables]; second, acid. A desirable accessory constituent is cane sugar. Too much sugar is likely to be used in jelly making, with a consequent deterioration of the quality of the jelly. The amount of inversion preferably produced in this cane sugar is yet undetermined.
>
> Overdilution of fruit juice [with water] should be avoided, since this leads to the use of too much sugar; probably the extra boiling thus rendered necessary also impairs the texture of the jelly.
>
> The physical constants of hot juice ready to jelly on cooling are, substantially, boiling point, 103° C., and specific gravity, 1.28.
>
> Jelly is readily made through boiling pectin with acid, water, and sugar.
>
> Jelly making seems to consist in so controlling conditions by means of acid and sugar and boiling as to cause the pectin to be precipitated in a continuous mass throughout the volume allotted to it.

The fall fruits used in these jelly-making studies were covered with cold water, brought to the boiling point, and thoroughly cooked, and the juice allowed to drip through a filter made of a double fold of cheese cloth.

> It was found that the pulp remaining on the filter could be again boiled up with water (the least amount possible) and that the resulting juice would make a good jelly. This was particularly true in the case of grapes, even the fourth and fifth extractions making an excellent quality of jelly—a quality better than that made from the first extraction because potassium acid tartrate crystals did not appear in it, as is usual in the case of jelly from grapes.

As previously stated, the presence of acid is considered essential for jelly making and a number of tests were carried on in which citric acid and tartaric acid, i. e., organic acids which occur normally in fruit juices, were used in different proportions.

From the results it appears then that—

> Through this addition of an organic acid to a fruit juice containing naturally little acid, jellies can be made if these juices contain pectin. However, the flavor of the fruit is generally changed; the sweet-apple jelly so made tasted much like that made from sour apples, the tartness of course increasing with increasing percentages of acid; the flavor of the pears, in pear jelly, was fairly well preserved, while in peach jelly the peach flavor was completely destroyed. Repeated experiments, varying the percentages of acid, were made in an endeavor to preserve the peach flavor, but success was not attained in this respect, though a jelly of fair texture could be produced. From experiments testing the relative merits of tartaric and citric acids in connection with the use of one or the other to acidify a fruit juice, the balance of favor seemed to be with the former. Both texture and flavor of jellies made by its use were superior to those in which citric acid was used.

These experiments are of special interest in view of the general household practice of adding sour fruit like currants or crab apples to sweet fruits like raspberries or elderberries to make a jelly of good consistency, and the even more common addition of lemon juice to jams and jellies made from a great variety of fruits. When currants or sour apples are thus used, pectin as well as acid is added, while with lemon the improvement in flavor is perhaps the consideration most often in mind, though many housekeepers realize that the lemon juice will make the material "jelly."

According to Miss Goldthwaite—

> That so-called jellies can be produced by merely boiling down fruit juices is well known. Naturally the flavor of such a jelly is decidedly fruity, but in texture it is very tough. The making of such jellies requires a large amount of juice, e. g., we found to make one glass of such apple jelly required a volume of juice sufficient for six glasses when made with sugar. Ordinarily, sugar is cheaper than fruit juice, so from the standpoint both of palatability and of economy (possibly also of digestibility) jellies made with sugar are preferable. * * * It seems better not to boil sugar and juice together from start to finish in jelly making, but rather to add the sugar so that it may be boiled with the juice for a period not to exceed one-half the total time of cooking.

Apparently the texture of the jelly may be greatly impaired by excessive cooking of an overdiluted juice.

The investigations summarized above not only furnish the housekeeper with information which is of use in jelly making, but also provide the teacher and student with additional data which is of value in understanding the physical and chemical problems which underlie this household process.

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FARMERS' BULLETIN 389.

BREAD AND BREAD MAKING.

BY

HELEN W. ATWATER.

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 31, 1910.

Sir: I have the honor to transmit herewith an article on Bread and Bread Making, prepared by Miss Helen W. Atwater in accordance with instructions given by the Director of this Office. In preparing this bulletin Miss Atwater has consulted the available sources of information, including standard works on the subject, as well as the reports of investigations relating to bread and bread making which have been conducted under the auspices of this Office, especially those carried on under the supervision of Director C. D. Woods, of the Maine Agricultural Experiment Station, and by Prof. Harry Snyder, at the Minnesota Agricultural Experiment Station.

Perhaps no topic connected with the subject of human food is of more general interest than bread, and no crops are more important to the farmer than the bread-yielding cereals. This bulletin, which summarizes the most recent information on the use of cereals for bread making, is believed to be useful and timely, and its publication as a Farmers' Bulletin is therefore recommended. It is designed to supersede Farmers' Bulletin No. 112, bearing a similar title and issued in 1900.

Respectfully,
A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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BREAD AND BREAD MAKING.

INTRODUCTION.

Probably no food, unless it is milk, is more generally used than bread, nor is there any food that constitutes a larger part of the diet of the average person. In the earliest historical records it is spoken of, and the wild tribes which to-day inhabit South Africa know something of its use. Of course, the bread made by the Kafir to-day, or by the American Indian three hundred years ago, is very different from that with which we are familiar. The Kafir simply grinds his grain between two stones, makes a paste of this meal and water, and bakes it in the ashes of his camp fire. Israel, in Egypt, ate leavened bread, the ancient Greeks cultivated the yeast plant, in Pompeii an oven was found containing loaves of bread not unlike that of the present day, many European peasants still bake their weekly loaves in the village oven, and so on, to the mammoth bakeries and innumerable fancy breads of modern times. The reason for this importance of bread is very simple. Ever since the far-off days when the wild cereals were first found or cultivated men have known that food prepared from them would support life and strength better than any other single food except milk. Although in this country the ease with which other foods can be obtained makes bread seem less important, there are many districts of Europe and Asia where it is still the "staff of life," and where if people pray for their daily bread they mean it literally.

Even in the United States it probably plays a more important part than many realize. Statistical investigations which have been conducted by the Government indicate that at present the annual per capita consumption of wheat in the United States is about 4½ bushels, which represents not far from a barrel of flour, and there are reasons to suppose that this amount is increasing. In the course of the 400 dietary studies made by the Office of Experiment Stations under a large variety of conditions, it has been discovered that wheat flour and other wheat products supply 20 per cent of the total food materials used by the average American family in the United States, 30 per cent of the total proteids, 5 per cent of the total fats, and 42 per cent of the total carbohydrates. If only patent flours and the bread made from them are considered they are found to supply 18 per cent of the total food, 20 per cent of the protein, 3 per cent of the fat, and 38 per cent of the total carbohydrates.

Because of the very general and extensive use of this article of food it seems desirable that the housekeepers in country and town and others who are interested should be given the means of understanding its composition, its nutritive value, and the best means of preparing it for use. For this reason the present bulletin has been prepared.

In regard to its ingredients, bread is one of the simplest of cooked foods, but in regard to the changes which the raw materials must undergo to produce a finished loaf it is one of the most complicated. Flour, water, a pinch of salt, and a little yeast—the necessary things can be counted on the fingers of one hand, yet the books which describe the processes of bread making with any degree of completeness are often large volumes. In this bulletin it is proposed to give a brief account of these processes—to describe the raw materials from which bread is made, and the changes which they undergo in the preparation and baking of the dough, with the significance of each to the quality of the bread and its value as food. But before going into a detailed description of these processes it will, perhaps, be well to recall not only what the main steps in bread making are, but also what characteristics food must have in order to be of greatest nutritive value to the human body.

In the flour mill, where the initial steps in bread making may be said to be taken, the grain is ground into powder, the coarser outer parts being sifted out as bran, while the finer interior parts constitute flour. Once in the baker's hands, the flour is mixed with water and yeast, or something which will produce the same effect. When this paste, or dough, containing yeast is set in a warm place the yeast begins to "work," and the dough to "rise;" in other words, the yeast causes a change known as "alcoholic fermentation" to set in, one of the principal results of which is the production of carbon-dioxid gas. If the dough has been well mixed, this gas appears all through it, and, expanding, leavens or raises it throughout. After the yeast has worked sufficiently the dough is shut up in a hot oven. Here the heat kills the yeast and prevents further alcoholic fermentation, causes the gas to expand and stretch open the little pockets which it has formed in the dough, changes some of the water present into steam, and expands any air mechanically included, thus raising the loaf still more. Further, the heat hardens and darkens the outer layers into what is called the "crust." The sum of these changes in the oven is called "baking." When this has been continued long enough the bread is "done" and is ready to be cooled and eaten.

The purposes which bread or any other food serves when it is taken inside the body have sometimes been compared to the use of coal in a steam engine, but the comparison is far from perfect. Food is the fuel which furnishes the energy for all the bodily activities, as coal furnishes the heat to make the steam which drives the engine, but it does more than this. It also builds the body engine and keeps it in repair. Hence there are two main functions which food must perform—to build up and keep in order the tissues and fluids of which human bodies are composed, and to furnish fuel or energy for their varied activities. Different as they look on the table, all food materials are found by the chemist to be made up of water and four different groups of substances which, in turn, play different parts in the building and running of the body machines, sometimes one or two and sometimes all of these constituents being present.

Water is found in varying quantities in almost all foodstuffs, even in such dry looking ones as flours; it is necessary to the body, and is usually available in sufficient quantities in the ordinary diet. Though necessary for carrying on the vital processes it does not build tissue or yield energy, hence it is not commonly classed as a nutrient or nutritive ingredient of food.

The four groups of true nutrients are protein compounds, carbohydrates, fats, and mineral matters or ash. The protein compounds include a great variety of materials, such as the albumen (white) of egg, the casein of milk curd, the lean of meat, and the aleurone and gluten of wheat and the similar bodies in other grains. They differ from other food ingredients mainly in that they contain nitrogen, and they are the only nutrients which can be used both to build tissue and to furnish energy in the body. The carbohydrates and the fats are fuel and not building foods. The carbohydrates include the different forms of starches, sugars, and cellulose or wood fiber and make up a large part of wheat and other grains. There are a great many kinds of fat in the different food materials; the more obvious forms are the fatty parts of meat, butter, fat, olive oil, etc., but some are also present in wheat and other grains. The fourth and last group of nutrients are the mineral matters or ash, which are found in very small quantities in foods but in great variety. During the period of body growth they supply the material out of which the bones and teeth are made, and at all times of life they perform many other important functions connected with body changes. An important point to be kept in mind about mineral matters is that while they are extremely important an ordinary mixed diet is believed to supply them in larger quantities than the body actually requires. For this reason under ordinary circumstances much anxiety with reference to securing enough mineral matter in the food is unnecessary.

Another important consideration in regard to the nutritive value of any food is its digestibility—that is, the completeness and ease with which it can be transformed by the digestive organs into the forms in which the body can utilize it.

GRAINS AND FLOURS.

Flours, as everyone knows, are made by grinding the grains of the various cereals—wheat, rye, barley, oats, maize, millet, rice, etc. One cereal may be more important in one part of the world, another in another, but probably in Europe and certainly in North America wheat is the leading breadstuff. This is partly because it can be successfully cultivated in a wide range of temperate climates, but chiefly because it yields the flour best suited to bread making, the aim of which is to produce an appetizing and nutritious loaf at the least expenditure of money and labor. While the various cereals differ largely in their chemical composition, most of them are very similar in the structure of their grains, so that a study of the formation and milling of wheat makes it easy to understand the production of flour from the others.

As a class the cereals may be said to contain on an average about 10 per cent of protein, a very small percentage of fats, and from 60 to 80 per cent of carbohydrates.

When the composition of cereals is considered, with reference to bread making, it is not enough to think of the amount of nutrients; the characteristics of the latter must also be considered. For example, the kind of cereal protein known as gluten is extremely tenacious and elastic. It captures and holds any gas which may come in contact with it, and for this reason it is most important in the making of light doughs. Other protein compounds, while of equal nutritive value, are wholly lacking in this quality. It is essential also to consider the amount of sugar present in the cereals, for this is the substance upon which yeast acts directly and out of which it can form carbon dioxid, the gas by which bread is usually made light.

WHEAT.

Structure.—The wheat grain (fig. 1) is a small oval seed, which can be easily thrashed from the stalk on which it grows. Its five outer layers are known as the bran. Of these the three outermost form what is called the skin of the grain, and constitute 3 per cent by weight of the entire seed. The two remaining layers of the bran form the envelope of the seed proper. The outer one is known as the "testa," and contains the greater part of the coloring matter of the bran. Inside it lies a thin layer of membrane. These two together form 2 per cent by weight of the entire grain. The layer next to the bran is called the cereal or aleurone layer. Its weight is about 8 per cent of that of the entire grain, making the total weight of the bran and aleurone layer together about 13 per cent. Within lie the starch-containing or flour cells which, with the aleurone, constitute the endosperm. The starchy portion comprises the larger part of the grain and consists of irregular-shaped cells containing the gluten-forming proteids and the starch granules. At the lower end of the grain, almost surrounded by the endosperm, lies the germ or embryo. A portion of the embryo is called the scutellum. When the grain has thoroughly ripened and is surrounded by favorable conditions this embryo will develop into a new plant. As it begins to grow it will feed upon the starch and other substances in the endosperm.

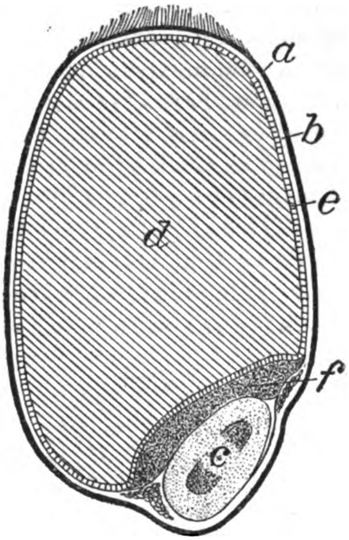

FIG. 1.—Diagrammatic section of grain of wheat: *a*, Skin and testa; *b*, membrane; *c*, embryo; *d*, flour cells; *e*, cereal or aleurone layer; *f*, scutellum.

The different parts of the wheat kernel are composed of cells varying in form and structure, but all too small to be seen except under a microscope. Figure 2 shows the cellular structure of a section of wheat cut from the surface into the endosperm, *a* and *b* being the two outer layers of the bran, *e* the rectangular cells which constitute the cereal or aleurone layer, and *f* some of the irregular cells which make up the floury portion of the endosperm. Each cell of the very large number making up the wheat berry is inclosed by a cell wall of woody fiber or cellulose, of which the thickness and character vary in different parts of the grain. Within each living cell is a network of nitrogenous material, called protoplasm by the biologists, thickening toward the middle of the cell into a nucleus, which is the center of cell life. Products formed by the plant, such as starch and fat, are stored in the portions of the cell not filled by this protoplasmic material. The character

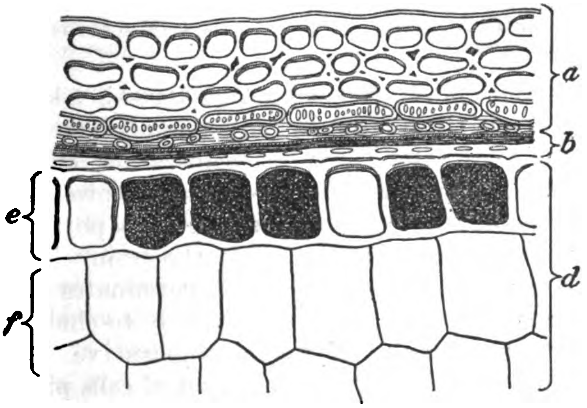

FIG. 2.—Cellular structure of a grain of wheat. (After Winton and Moeller.)

of the cell contents varies considerably in different parts of the wheat berry, starch being characteristic of the interior of the grain rather than the outer portions. The large rectangular cells of the cereal or aleurone layer are filled with a nitrogenous material known as cerealin or aleurone. The cells of the germ, which are not shown in the diagram, contain a large proportion of fat.

Since flour is the most important product of wheat, and since it is made up largely of the flour or starch cells of the endosperm, these are of especial interest in this connection. Figures 3 and 4 show diagrammatically the protoplasmic network (in this case gluten) of a single flour cell with its nucleus and the starch grains which would be embedded in the network. If we conceive these figures (3 and 4) united so that the starch grains would be embedded in the protoplasmic network, we have a picture of a single starch cell. The starch grains are of various sizes, and there are several hundred in a single cell, and from 10,000,000 to 20,000,000 in a kernel of wheat. In addition to starch, the flour cells contain mineral matter and a very small proportion of fat. These diagrams show clearly that the interior portion of the wheat berry consists of protein and starch, and not of starch only, as is sometimes claimed by popular writers.

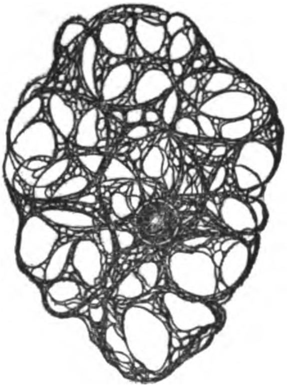

FIG. 3.—Diagram of protoplasmic structure of a flour cell.

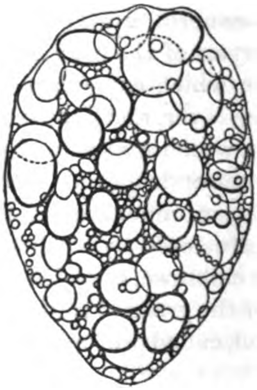

FIG. 4.—Diagram of starch grains in a flour cell.

The many changes which take place in the grain while it is stored, when it is made into flour, or when it germinates and begins to grow and form a new plant, are due primarily to changes in the cell protoplasm. The character of the protoplasm varies in different parts of the kernel, indicating that each set of cells plays a different rôle in the development of the grain. Moreover, marked differences are found in the character of the cells of different varieties of wheat, and it is believed that wheats may be accurately classified according to the characteristics of their flour cells.

The knowledge of the protein compounds of the wheat kernel has been much increased lately, notably by the elaborate work of Osborne[a] at the Connecticut Agricultural Experiment Station. These compounds are more varied than was formerly supposed, but the most important fact to be remembered in connection with bread making is the character of those in the endosperm. Gluten is the term formerly employed to describe them and still in common use; but it should be borne in mind that gluten is not a simple compound, but one which itself contains several kinds of protein. Of these gliadin and glutenin are the most abundant and in the present discussion the most important. As will be seen later, the bread-making power of a flour depends largely on the relative amounts of gliadin and glutenin which it contains.

The cellulose also differs in character in different parts of the grain, being both more woody and more abundant in the outer layers which are ordinarily sifted out from the finer grades of flour. The proportion of cellulose carbohydrate which the body can utilize depends upon the character of the cellulose, woody cells being little digested while cell walls of softer texture are apparently rather well digested. Between these extremes are many variations. The portion of the grain called the testa contains coloring matter, and it is the presence of this which makes flour dark.

Grain, being hygroscopic—that is, having the power of absorbing water from the atmosphere—varies with the weather in the amount of moisture which it contains; similarly, wheat grown in a wet season or a humid climate holds a larger percentage of moisture than the same kind grown under drier conditions. Thus English wheat contains on an average 3 or 4 per cent more water than American. From a comparison of many analyses the average weight of the water in the grain is found to be about 12 or 13 per cent of its total weight.

Milling.—When people first began to grind their grain they did so simply by crushing it between any two stones which happened to be at hand; a little later they kept two especially for the purpose, one of which they soon learned to keep stationary while the other was turned about on it. At first each woman ground the meal for her own family on her own stone; but after treadmills, windmills, and, later, water wheels came into use all the grinding was done by the professional miller in the village mill. In feudal days the lord forced his tenants to have their grain ground in his mill, even to bake their bread in his oven, and charged a good round toll for the use of each. Various devices for grinding and sifting the grain have gradually been invented, until to-day mills have been built covering acres of ground.

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[a] Carnegie Institution of Washington, Publication No. 84, 1907.

In Hungary the old Roman system of cylinder milling has been developed, but elsewhere the systems which are known as high and low milling are more common. This is the original system of crushing between two stones or rollers, but so elaborated as to be almost unrecognizable.

In low milling the grain is ground in one process between two crushers placed as near together as possible. Graham flour is commonly produced in this way. This milling product, advocated by an American physician, Dr. Sylvester Graham, is really wheat meal containing all of the grain; it is made by simply cleaning the grain and then grinding it between two stones or rollers, whose surfaces are so cut as to insure a complete crushing of the grain.

In high-roller milling the grain is screened and cleaned and then tempered; that is, treated with heat and moisture in such a way as to make it easier to remove all the bran at one grinding. After removal of the bran, the stock is run through five or even more pairs of rollers, each successive pair being set a little nearer together than the last pair. After each grinding, or "break" as the miller terms it, the fine flour is sifted out, and the leavings of each sifting, called "middlings," are themselves ground and sifted several times. In a mill where the grain goes through a series of six straight breaks there are as many as eighty direct milling products, varying in quality from the finest white flour to pure ground bran. Careful millers always try to grind as near the aleurone layer as possible, and to leave as much of the germ in the flour as is consistent with a good color. To make sure that each product is up to the standard set for it in the mill, samples of it are frequently tested and the milling is regulated accordingly.

The so-called "straight grade," "patent," "standard," and "household" flours found on the market are made by blending different milling products in such a way as to give the flour the desired characteristics. The modern roller milling retains a much larger proportion of the wheat berry, and gives a much smaller proportion of bran and other "offal products," as these by-products of milling are termed, than the older methods of milling. Entire-wheat flour is produced by high roller milling, and differs from ordinary flours mainly in that the inner portions of the bran, with the aleurone layer, are included.

The accompanying table shows the chemical composition of various milling products and American wheat flours. Such data might vary for different kinds of wheat, or for the same wheat grown in different regions, or in the same region in different seasons. But the analyses here shown are (with the exception of those for gluten flours) those for products all milled from the same lot of Minnesota hard spring wheat, hence they are strictly comparable with one another.

Analyses of wheat and the products of roller milling.

Milling product.	Water.	Protein (N × 5.7).	Fat.	Carbohydrates.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
First patent flour	10.55	11.08	1.15	76.85	0.37
Second patent flour	10.49	11.14	1.20	76.75	.42
First clear-grade flour	10.13	13.74	2.20	73.13	.80
Straight or standard-patent flour	10.54	11.99	1.61	75.36	.50
Second clear-grade flour	10.08	15.03	3.77	69.37	1.75
"Red dog" flour	9.17	18.98	7.00	61.37	3.48
Shorts	8.73	14.87	6.37	65.47	4.56
Bran	9.99	14.02	4.39	65.54	6.06
Entire-wheat flour	10.81	12.26	2.24	73.67	1.02
Graham flour	8.61	12.65	2.44	74.58	1.72
Wheat ground in laboratory	8.50	12.65	2.36	74.69	1.80
Germ	8.73	27.24	11.23	48.09	4.71
Gluten flour, true to name	9.99	84.09	.66	5.01	.22
Gluten flour, not true to name	8.57	16.36	3.15	70.63	1.29

If, as often happens, it is desirable to blend two kinds of wheat in order to obtain a flour with the average of their qualities, the grains are usually mixed before milling. Sometimes the miller, or even the baker, mixes two kinds of flour, but such a proceeding seems to be regarded by the users of flour as less satisfactory because it gives less uniform results.

Tests for quality.—Very complicated chemical tests are necessary to determine the exact quality of a flour, but there are certain general rules by which a good bread flour may be judged offhand. In general, the flour housewives prefer is white with a faint yellow tinge. After being pressed in the hand flour should fall loosely apart; if it stays in lumps it has too much moisture in it; when rubbed between the fingers it should not feel too smooth and powdery, but its individual particles should be vaguely distinguishable; when put between the teeth it should "crunch" a little; its taste should be sweet and nutty, without a suspicion of acidity. Wholesale bakers usually demand a more granular, darker flour and one with a greater power of absorbing water than is ordinarily chosen for household use; they also make careful baking tests with each fresh lot of material, and as each barrel which leaves the first-class mills is individually numbered, it is possible to trace back to their source any undesirable characteristics if they should be noted. Housekeepers who buy flour under fancy trade names have less opportunity of knowing the character of the product, nor does it ordinarily seem worth while to make baking tests for the small quantities purchased for home use; but an intelligent housekeeper who wishes to know the quality of the flour she is buying could easily learn from the dealer or the miller the character of different brands and could use samples to compare their bread-making qualities in her own kitchen before buying her supply for the season.

Possible impurities of wheat flour and the ways in which they may be avoided.—Certain impurities may accidentally occur in a bag of grain or the flour made from it. They consist mainly of seeds of other plants, some of them harmful to color or flavor, and of blighted or molded grain. Modern methods of sorting and cleaning the grain in well-conducted mills almost eliminate the danger of foreign seeds and careful methods of storing make the dangers from molds and other fungus growths much less than formerly. Careful milling processes also tend to remove such accidental impurities as bits of sand, earth, or metal which occasionally slip in.

Of course flour which is in good condition when it leaves the mill may deteriorate if it is not properly cared for. All such products are attractive fields for molds and bacteria, and in their growth these minute organisms may spoil the flavor and bread-making qualities of flour. Dampness and darkness are very favorable to their growth, hence dry, well-lighted storerooms are the best for flour. Damp, dark cellars should not be used for storing any cereal products. The color of flour, like many natural colors, fades more or less during storage and the flour becomes whiter.

RYE.

The grain of rye is darker in color than that of wheat, but is otherwise similar in appearance. Rye flour differs from wheat flour in flavor, the liking for the one or the other being a matter of preference. It differs, however, in another way and in an important particular—its gluten has not the same elastic, tenacious quality and does not yield so light and well-raised a loaf. Although this fact and its dark color make it less popular than wheat, it is second in importance as a breadstuff. It is more easily raised than wheat, especially in cold countries, and therefore generally has a lower market value. In many parts of Europe it practically replaces wheat among the poor and in army rations. When it is milled entire, as it usually is, it contains more protein than wheat flour, but is probably less completely digested. Wheat and rye flour are often used together in bread making.

BARLEY AND OATS.

These cereals are so seldom used in bread that a short description of them will suffice. In general structure their grains are not unlike those of wheat and rye, but their composition differs noticeably. In both barley and oats the bran makes up a higher percentage of the entire grain than in wheat. Both oats and barley on an average contain less moisture than wheat. They do not contain any true gluten (which appears in wheat and rye), and although their other nitrogenous ingredients make them comparatively rich in proteid nutrients, they do not yield a light, attractive loaf. Bread made from them also contains a large proportion of relatively indigestible cellulose.

CORN, OR MAIZE.

This cereal, generally known in the United States as Indian corn, and on the continent of Europe as maize, is a native of America. It is commonly grown in North and South America, Africa, India, China, and southern Europe, especially Italy and the Balkan regions, and is slowly being introduced into other European countries. The hull of the kernel is thin and tender, the endosperm abundant and mealy, the germ comparatively large. The diagrammatic drawing of a section of a kernel of corn (fig. 5) shows the distribution of the several parts and the relative proportion of each. Figure 6 shows the character of the cells making up the skin and testa, membrane, and endosperm. Each cell has an outer wall of cellulose varying somewhat in thickness and character in the different parts of the grain. Within the cell is a proteid network, the cell nucleus, the starch and other products of cell activity being embedded in this protoplasmic material. The character of the cell contents varies in different parts of the grain, the cells in the endosperm being characterized by the presence of large amounts of starch and those in the germ by fat. The kernels are generally white or yellow. Compared

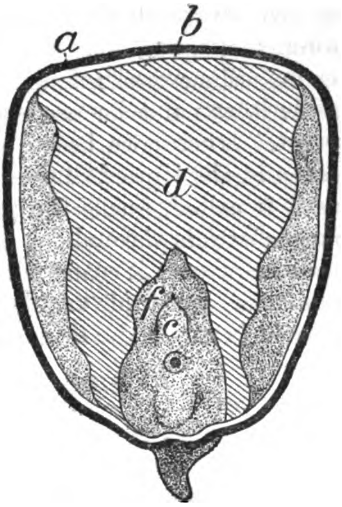

FIG. 5.—Diagrammatic section of grain of corn: a, Skin and testa; b, membrane; c, embryo; d, endcsperm; f, scutellum.

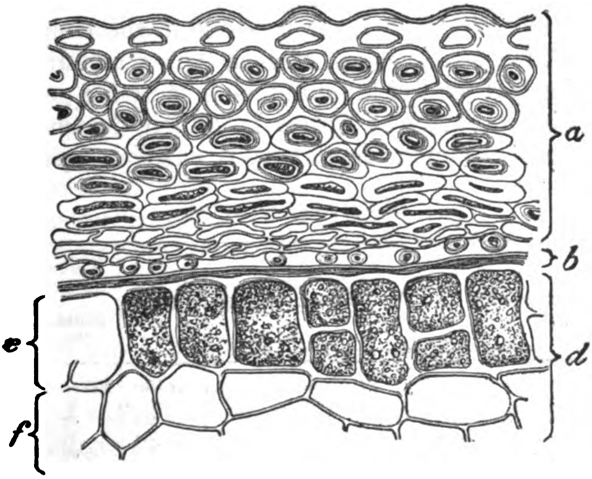

FIG. 6.—Cellular structure of a grain of corn: a, Skin and testa; b, membrane; d, endosperm, consisting of aleurone cells (e) and starch cells (f). (After Winton and Moeller.)

with wheat, maize is rich in fat, poorer in cellulose and protein, and about equal to wheat in carbohydrates, mineral matter, and moisture. Most of its fat is in the embryo or germ, which in milling is often removed to prevent the flour or meal becoming rancid. Maize flour makes very nutritious and appetizing unleavened bread, hoecake, johnnycake, etc., but these dry so quickly that they must be eaten fresh. Since maize flour contains no tenacious, gluten-forming proteids it can not be used alone to produce a good loaf raised with yeast. Much corn bread and other foods made from corn meal are eaten in the United States. In Italy corn-meal mush, or "polenta," as it is called, forms the principal article of diet of the peasants in large districts throughout a considerable part of the year. In Servia the unripe corn is eaten much as in this country, and corn-meal bread and mush are staple articles of diet. In the Orient, corn where grown is used in much the same ways as other grains.

RICE, MILLET, BUCKWHEAT, ETC.

Rice, which is grown and eaten to a large extent in the United States, is the most important cereal in China, Japan, and other oriental countries. Much millet is eaten in China, India, and Russia; sesame is also largely used by the native races of India and China, and in the United States buckwheat is often made into batter cakes. Yet none of these as a rule takes the place of bread to any extent except in some oriental countries. In some regions of Russia, however, buckwheat porridge is the principal cereal food. Grain sorghums, especially Blackhull Kafir, are used in the United States to a limited extent for batter cakes, etc. In Africa and India they form the principal cereal food of large numbers of native peoples.

The following table gives figures by which the chemical composition of the most common cereals may be easily compared:

Composition of cereals.

Kind of cereal.	Water.	Protein.	Fat.	Carbohydrates.		Ash.
				Starch, etc.	Crude fiber.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Barley	10.9	12.4	1.8	69.8	2.7	2.4
Buckwheat	12.6	10.0	2.2	64.5	8.7	2.0
Corn (maize)	9.3	9.9	2.8	74.9	1.4	1.5
Kafir corn	16.8	6.6	3.8	69.5	1.1	2.2
Oats	11.0	11.8	5.0	59.7	9.5	3.0
Rice	12.4	7.4	.4	79.2	.2	.4
Rye	11.6	10.6	1.7	72.0	1.7	1.9
Wheat:						
Spring varieties	10.4	12.5	2.2	71.2	1.8	1.9
Winter varieties	10.5	11.8	2.1	72.0	1.8	1.8

YEAST AND OTHER LEAVENING AGENCIES.

THE THEORY OF FERMENTATION.

When a little yeast is added to a sweet liquid like fruit juice and kept warm, bubbles appear until the whole mass seems to be boiling. If the liquid is analyzed after the yeast has so worked in it for a time it will be found to contain less sugar than at first; the amount of yeast will have increased, and alcohol and carbon dioxid will appear in considerable quantities. The explanation is this: The yeast, which is really a mass of tiny plants, has reproduced again and again, and in this growth has fed upon the sugar of the liquid and given off alcohol and carbon dioxid. Such a phenomenon is called "alcoholic fermentation," and is essentially the same as that which "raises" a loaf of bread. Such fermentation is by no means the only kind which occurs in common life. The souring of cider into vinegar, for instance, is due to another kind. In that case a variety of microscopic plant develops in large numbers in the cider, and in so doing produce, first, alcohol, and then acetic acid, which gives vinegar its characteristic taste. This latter process is called "acetic fermentation." Similarly, if another variety of bacteria gets a chance to develop in sweet milk it gives rise to lactic fermentation, during which is produced the lactic acid which turns the milk sour. Rancidity of butter is due to the so-called butyric fermentation. Here the bacteria yield butyric acid, which gives such butter its disagreeable taste and odor.

These microscopic plants and many others are widely distributed in the air, and often find their way accidentally into different materials, where they grow and multiply, causing fermentation, just as thistle seeds, for instance, are blown about in the air until they lodge in some favorable spot and grow. At other times special forms of ferments in so-called "pure cultures" are purposely added to some material, just as seeds of larger plants are purposely sown in the garden. Thus pure cultures of certain microscopic organisms are added to cream to improve the flavor of butter and make it uniform in quality. This insures a special fermentation instead of the accidental fermentation which would otherwise occur. The term "fermentation" was first applied to the action of yeast plants on sugar with the formation of carbon dioxid and alcohol. There is another class of chemical changes to which the term "fermentation" is applied. Such changes are produced by chemical substances called enzyms, which are not living organisms, but which are produced by living organisms. Ferments may therefore be divided into two classes, (1) the organized ferments, such as yeast, bacteria, etc., and (2) unorganized ferments, or enzyms. Human saliva contains an enzym called ptyalin, which is much like diastase, and capable of producing a similar effect on starch. The pepsin and trypsin of the digestive juices are also enzyms.

It is a peculiar feature of the organized ferments that they affect a much larger amount of the material on which they feed than goes to their own development, and this in spite of the rapidity with which they multiply. Thus yeast converts much more sugar into alcohol and carbon dioxid than it consumes in its own growth and reproduction. Moreover, when the fermentation ceases the yeast plant remains; in other words, the fermentation has been produced without changing the nature of the agent producing it. In the same way the enzyms cause fermentation without being themselves changed. Though much has been learned in recent years concerning fermentation, there still remain many things to be explained. It is known what changes take place and under what conditions, but just why they take place is not so clear. It is a remarkable fact concerning ferments that in time the substances they produce put a stop to their activity. Thus the alcohol produced by the yeast is in time sufficient to hinder the growth of the yeast plant and ultimately to kill it. If, however, the products of this activity are removed, the ferments resume work, even though the original yeast is killed.

YEAST.

Keeping the above facts in mind, it is easy to understand the leavening effect of yeast in dough. The yeast, "working" in the warm water and flour, feeds on sugar[a] originally present or else produced from the starch by diastase, grows and spreads throughout the dough, at the same time giving off carbon-dioxid gas, which forces its way between the tenacious particles of gluten and lightens the dough.

Scientifically speaking, yeast is a minute fungus of the genus Saccharomyces. A single plant is a round or oval one-celled microscopic body (fig. 7), which reproduces in two ways—either by sending out buds which break off as new plants or by forming spores which will grow into new plants under favorable conditions. It grows only in the presence of moisture, heat, and nutritive material. If the moisture is not abundant, the surrounding substances absorb that which already exists in the yeast cells, and so prevent them from performing their functions. Yeast develops best at a temperature of 77° to 95° F. (25° to 35° C.). It has already been seen how yeast uses up sugar in its growth. It is also believed that some nitrogen is necessary for the best development of yeast, and that such development is most complete in the presence of free oxygen, but why these things are so is not yet clearly understood.

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[a] The sugar upon which yeast is said to feed in its growth is not necessarily such sugar as we ordinarily use to sweeten our food. The word sugar is here used in its broader, scientific sense. All starches and sugars, it will be remembered, are grouped together by chemists under the name of carbohydrates. They are chemical compounds of carbon, oxygen, and hydrogen, and differ from each other in the proportion of oxygen and hydrogen to carbon which they contain. For a more extended discussion of sugar see U. S. Dept. Agr., Farmers' Bul. 93.

Yeast is literally as old as the hills. It must be present in the atmosphere, for if a dish of malt extract, originally free from yeast, be exposed to the air, alcoholic fermentation, such as could be produced only by yeast, will soon set in. Such yeast is known as "wild yeast," and all yeasts have been cultivated from it. The oldest method of growing yeast is, perhaps, that used by the Egyptians. A little wild yeast was obtained and set in dough, a portion of which was saved from the baking; there it went on developing as long as materials held out, and thus the bit of dough or "leaven" contained so much yeast that a little of it would leaven the whole loaf. It was such leaven as this which the Israelites had not time to put into their bread when they were brought out of the land of Egypt. A microscopical examination was recently made of some bread over four thousand four hundred years old, found in Egypt, with other remains of a long-vanished people. It was made of barley, and the dead yeast cells were plainly visible. A similar process of raising bread with "leaven" is still carried on in some regions of Europe. The "wet yeast" or "potato yeast," so common in this country before the days of yeast cakes, was made by a similar method. Wild yeast was cultivated in a decoction of hops or potato and water, and some of the material thus obtained was mixed with the dough. The "barms" so much used in Scotland are made by letting yeast grow in malt extract and flour (p. 24). Brewers' and distillers' yeasts are taken from the vats in which malt extract has been fermenting. Compressed yeast is made with yeast taken from distillers' wort, washed in cold water, and further cleaned by being passed through silk or wire sieves or by precipitation. It is then pressed, cut into cakes, and done up in tinfoil. When fresh it becomes firm, moist, and of a light, creamy color throughout. On account of its moisture, it soon decomposes unless it is kept in a cool place. Dry yeasts are prepared by mixing

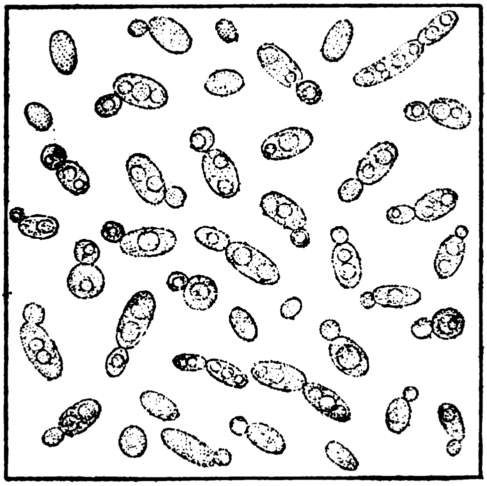

FIG. 7.—Yeast plant.

fresh yeast with flour, meal, or starch, pressing the mixture into little cakes, and then drying them. Without moisture the yeast cells must remain inactive, and well-made dry yeast should keep for a long time. The strength of any yeast depends on the care with which it is made and preserved. Ordinary liquid yeasts are likely to be full of the bacteria which set up lactic or other fermentations in the bread and give it a disagreeable taste and odor. They are very susceptible to changes in the weather and can not be always relied on. Compressed and dry yeasts, if carefully made, are more uniform in strength and composition than such liquid yeast. Usually a few of the microscopic plants or bacteria other than yeast plants are not regarded as a detriment, as the slight acid taste which their presence gives to the bread is considered desirable by many.

SUBSTITUTES FOR YEAST.

Partly because yeast is uncertain in its workings, partly, too, because it uses up some of the nutritive ingredients of the bread by feeding upon them, attempts have been made to find some substitute for it. Various chemicals have been used to produce carbon-dioxid gas in the dough. The first noteworthy attempts were made about the middle of the nineteenth century at Harvard University and in Germany. Yeast powder, as the American preparation was called, was a mixture of an acid and an alkaline powder, the former calcium phosphate and the latter bicarbonate of soda. When duly mixed with the dough, these were supposed to give off carbon dioxid as effectively as yeast. Liebig, who calculated that in Germany the daily loss of material by the growth of the yeast plant was, if saved, sufficient to supply 400,000 persons with bread, made a great effort to introduce a similar preparation into Germany, but with little success. Numerous baking powders, made from various chemicals, are in the market now. The self-raising flour used in the United States is a flour ready mixed with such a preparation. In the United States leavening agents other than yeast are more commonly used for such kinds of bread as tea biscuit and batter cakes, or for cake and pastry, than for loaf bread. Soda, cream of tartar, or saleratus biscuit are examples of breads frequently made in the home with these chemical leavening agents.

The "aerated bread," so popular in London, is made by a different method, invented by the English physician Dauglish in 1856. According to this method, the water used for wetting the dough is directly charged with the requisite amount of carbon-dioxid gas and then mixed with the flour in a specially constructed machine. Sometimes a little fermented barley infusion from a brewery, or "wort," is put into the water. This renders the gluten more elastic, aids in absorbing the gas, and improves the flavor of the bread. The bread is about as porous as that raised with yeast, but is less agreeable to the taste of many persons, apparently because of a lack of the by-products resulting from the action of the yeast in the fermentation process.

The so-called "salt-rising" bread is interesting as an illustration of self-raised bread. In it the ferments originally present or acquired from the air produce the fermentation which leavens it. To make it warm milk and corn meal are mixed together into a stiff batter which is left at blood heat until the whole mass is sour—that is, until the ferments present have produced fermentation throughout. Next a thick sponge is made of wheat flour and hot water in which a little salt has been dissolved. This sponge and the sour batter are thoroughly kneaded together and set in a warm place for several hours. The leavening action started in the batter spreads through the dough and produces a light, porous loaf, which many persons consider very palatable. Such a bread is comparatively free from acidity, as the presence of the salt hinders undesirable acid fermentation.

RAISED BREAD, GENERAL METHODS.

Ordinarily a baker mixes his dough with water, and most of the data summarized in this bulletin refer to such bread. Sometimes, especially in private families, milk is used in the place of part or all of the water. Such dough is slower in rising but makes an equally light loaf. Milk bread contains a larger percentage of proteids and fats than water bread, and is equally digestible. Its use is by all means to be advocated, especially on farms where skim milk is abundant.[a] When water is used it should, of course, be free from any dirt or contamination. Its hardness or softness makes little difference in the quality of the bread, though perhaps the softer water is to be preferred. Salt is used in bread because it imparts a flavor without which bread is usually considered insipid, and because it exerts a retarding influence on the diastase by which starch is converted into sugar, and on other ferments.

When the flour is of good quality, the dough well prepared, and the bread properly baked, the loaf has certain definite characteristics. Thus it should be well raised and have a thin, flinty crust, which is neither too dark in color nor too tough, but which cracks when broken. The crumb, as the interior of the loaf is called, should be porous, elastic, and of uniform texture, without large holes, and should have a good flavor and odor. In this connection the breadmaking and judging contests in some of the household science departments of the farmers' institutes are of interest. The members are urged to bring loaves of their own baking to the meetings, and these are judged on such points as flavor, lightness, grain and texture of the dough, color, depth and texture of the crust, and marked on special score cards with as much accuracy as is used in seed or stock judging contests among farmers. If housekeepers would judge the bread baked in their own kitchens with the same intelligent interest and profit by their findings they could soon learn to make bread as accurately as wholesale bakers.

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[a] See articles on the digestibility of bread in Maine Sta. Rpt. 1898. Also U. S. Dept. Agr., Office of Experiment Stations Bul. 85.

PREPARATION OF THE DOUGH.

The methods of mixing dough are various, but certain general rules apply to them all. As yeast develops best at a moderately high temperature (77° to 95° F.), the materials of the dough should be at least lukewarm, and the mixing and the raising should be done in a warm place, as free as possible from drafts. On the other hand, too high temperatures must also be avoided, as they kill the yeast. If all portions of the dough are to be equally aerated by the gas from the growing yeast, the latter must be thoroughly mixed with the flour and water; moreover, as the presence of oxygen aids the growth of the yeast, all parts of the dough should be exposed to the air. Both these results are accomplished by the kneading. Too little yeast will, of course, yield a badly raised loaf, but too much yeast is just as objectionable, as the bubbles formed in the gluten of the flour, unable to resist the pressure of the excessive amount of gas, break open, the gas escapes, and the dough becomes heavy and soggy. Too much yeast also gives an unpleasant "yeasty" taste to the bread, due partly to the presence of superfluous yeast cells, but more especially to other ferments. Even when used in small quantities, yeast has a decided influence on the flavor of the bread. The amount of yeast which should be used depends on the strength of the flour. A flour in which the gluten is abundant and tenacious can resist a much stronger pressure of gas than one with scant or weak gluten, which, if it does not fall entirely, is likely to make a loaf with large holes and heavy, badly raised masses between. Similarly, the proportion of water which should be used varies with the strength of the flour. The standard cookbooks suggest an average of about three parts of flour to one of water, the ratios changing with the quality of the flour. In general nothing but practical experience with the materials can teach the exact quantities which should be mixed. Salt, as has been said, tends to retard fermentation, and consequently should be added toward the end of the mixing; then it is useful because it checks lactic or butyric fermentations, such as often follow the alcoholic fermentation.

It seems almost unnecessary to say that the greatest cleanliness should be observed in kneading bread. Many household cooks maintain that it is impossible to mix dough as evenly with a knife or spoon as with the hands, though expert cooks insist that perfect mixing may be obtained by the use of a knife. Within a few years household "bread machines" have become more and more popular, and several kinds are found on the market, each having its advocates. In one of these a peculiarly bent rod, turned by means of a crank, mixes the dough thoroughly and perhaps more evenly and quickly than the ordinary kneading. In another form the dough is mixed by revolving knife-like devices. These machines seem to give excellent results and are to be recommended at least as labor saving and cleanly. Perhaps where bread is made in small quantities and every precaution is taken to insure cleanliness, the use of the hands may be tolerated, but the practice was long ago given up in wholesale bakeries of good grade where dough is mixed in such large quantities that the kneading is violent physical exercise and the worker is unable to take his hands from the dough long enough to wipe his dripping forehead. In high grade establishments modern kneading machines, in which revolving metal blades do the work of the hands, are in general use, as well as other ingenious machinery; it is even possible to turn out bread in which none of the materials have been touched by hand from the time they enter the bakery until the loaves are taken from the oven. Every utensil used in making and handling bread should be scrupulously clean, not only because it is desirable for food to be clean but because otherwise bacteria may get into the dough and produce harmful fermentations which mean loss to the housekeeper or the baker.

Bread making, as practiced in large bakeries, differs from that as practiced in households more in the amount of materials used and the consequent need of mechanical devices than in any fundamental principles. The question of the amount of bread to be obtained from a given quantity of flour and yeast plays a more important part in bake shops, and of course influences the choice of methods of preparation as well as of the flour to be used.

The ways of mixing dough most used in this country by bakers are probably those known as "straight dough" and "sponge dough."

Straight dough, or "offhand" dough, as it is sometimes called, is made by mixing all the materials at one time, and then setting the mass in a warm place to rise for ten hours or more before baking. It requires more yeast and stronger flour than other methods in which the yeast is allowed to grow in an especially favorable medium before being mixed with the main dough, and needs a longer time to rise, but on the other hand gives an unusually large yield in bread. It is convenient in family bread making, especially when strong compressed yeast is used, as the dough can be mixed overnight and baked in the morning. Some wholesale bakers dislike it because the dough is stiff and hard to knead, because the large quantities of materials used at one time require extensive kneading apparatus, and because the bread is usually coarse in texture, with a raw, grainy taste, due to the strong flours used.

Sponge dough.—This method is best adapted to fancy working, and makes equally good crusty loaves or light biscuit. To make the "sponge," as the bread mixture is commonly called, the yeast is allowed to work for eight or ten hours in a portion of the flour or water. This is then mixed with the remaining materials and left to rise a few hours before baking. The sponge is "slacker"—that is, contains more water than offhand dough, and thus gives the yeast a better chance to work. Bakers usually set their sponge with a strong flour, which gives it a light, elastic quality; a little salt is put into it to prevent lactic fermentation. A weaker flour may be used in the second mixing, as the greater part of the gas has already been given off in the sponge, and no great pressure will come on the newly added gluten. If strong flour be used instead, the bread yield will be greater, but the mild, sweet flavor imparted by the weaker kinds will be replaced by the harsh taste noticed in bread made from offhand doughs. Great care must be taken to mix in the second lot of flour thoroughly, or the bread will be full of hard lumps on which the yeast has had no effect. Sponge-made bread usually rises evenly and well, and can be worked into almost any shape. It has the further advantage of keeping well. It requires longer labor than the method described before; still the difference is really that between two short kneadings in soft dough and one long one in stiff dough. Like offhand dough, it can be started the night before it is baked.

There are of course various other ways of mixing dough with yeast in bakeries, but the ones just described are sufficient to illustrate the general principles involved.

Scotch barm methods.—Probably the majority of European bakers now use yeast in ways similar to those followed by Americans, but in some regions other leavening methods are still common. Thus, many Scotch bakers still use barm, which is literally the foamy scum which rises to the top when beer, etc., is made. To make barm in the household malt is crushed in warm water, hops and boiling water are poured over it, then flour is added, and the mixture is allowed to stand until the starch granules from the flour have been burst open by the hot water and the starch thus freed has been changed into sugar by the diastase of the malt. A sweet liquid is drained off from this and mixed with flour and water, the resulting sticky mass being subjected to the action of yeast, either acquired spontaneously by exposure to the air (virgin barm) or added in the form of a little old barm or ordinary yeast (Parisian barm). The fermentation thus started is allowed to continue several days and then the barm is ready for use in the sponge. A strong flour is needed for both the barm and the dough, and consequently the bread yield is large. Scotch bakers consider this method most economical, because there is practically no yeast to be bought and the flour used in the barm goes into the bread. These arguments seem hardly tenable, however. The cost of labor in preparing the barm must be considerable and at least a portion of the flour in the barm is lost in the form of alcohol and carbon dioxid. Moreover, while the barm is exposed to the air in making, it takes in a great many bacteria which start lactic and other fermentations and give a decidedly sour taste to the bread. To be sure, persons accustomed to such bread find an ordinary sweet loaf insipid. Still, such a flavor would probably not be acceptable to the average American palate.

BREAD MADE WITH LEAVEN.

In some parts of the continent of Europe the age-old method of raising bread by leaven is still practiced. According to a French authority,[a] a little of the dough ready for baking is saved and mixed with an equal amount of flour and water and is allowed to stand four or five hours. This operation is repeated three or four times before the leaven is ready to be mixed into the actual dough. This gradual mixing of the leaven is preferred because in this way the yeast is allowed to act on one lot of flour only for a short time, then before it has become exhausted and other fermentations set in new yeast food is added, and thus a large number of yeast cells is supposed to be produced along with relatively few lactic and butyric acid bacteria. In spite of this precaution bread made with leaven has a much more acid taste than that made with yeast, especially if the leaven has been kept some time. Anyone who has eaten the bread ordinarily made by the poor country people of France or Switzerland will willingly testify to this. More leaven is required in winter than in summer, because the yeast develops less quickly in cold weather, but on the average the leaven should form one-third of the entire dough. Bread made with leaven generally has large, irregular holes in its crumb. This is attributed to the fact that the bacteria in the leaven give rise to a ferment (diastase) and acids, which tend to soften the gluten.

Boutroux considers bread made with leaven more healthful than that made with yeast, because the acids it contains aid in its digestion. He also maintains that leaven is more reliable than the yeasts ordinarily found in the French market, but probably the majority of experts in this country would hold that the best of the commercial yeasts are more reliable and much more convenient.

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[a] Le pain et la panification, L. Boutroux. Paris, 1897.

Rising of dough.—After mixing the dough in the way considered most desirable it is set in a warm place (77° to 95° F.) to rise. Here the yeast continues to work and the gas given off stretches the spaces between the particles of dough. If the gas is allowed to go on increasing until its pressure is greater than the elasticity of the gluten can resist, the latter breaks apart, leaving large holes throughout the dough. If such "overproved" dough is kneaded a little before it is put into the oven the excessive gas will be forced out and the holes will be more regular.

HOUSEHOLD METHODS OF BREAD MAKING.

In different regions somewhat different ways of making bread in the household are popular, and, indeed, each bread maker is apt to believe she has some especially valuable way of mixing or kneading. These differences are not so important as is sometimes supposed, and, as has been said, the general principles followed in bread making at home are the same as in bakeries. What are perhaps the two most popular ways of making bread at home are sometimes called the "quick-raising method" and the "slow-raising method."

Quick-raising method.—A stiff dough is made of the flour, water, and yeast. It is thoroughly kneaded and is then allowed to rise until it doubles its bulk, when it is again kneaded thoroughly. After rising a second time it is baked. In the quick-raising process a large quantity of yeast is used, and the time of fermentation is only about two and a half hours. The baking is completed in about four or five hours after the bread is first started to rise.

Slow-raising method.—A batter is made of the flour, yeast, and water, which is allowed to ferment ten or fifteen hours, usually overnight. More flour is then added; the dough is kneaded until smooth, and then allowed to rise and is treated in the same way as in the first method. In the slow-raising method less yeast is used than in the short process, and the fermentation is carried on for a longer time. The usual temperature at which the fermentation thus takes place is perhaps not far from 70° F.

Various forms of "raised biscuits," "hot bread," etc., are made in the household by adding shortening, milk, eggs, etc., to the dough, or by modifying in some way the process followed. Sometimes baking powder of some sort is used as a leavening agent instead of yeast, and the form of bread called "baking-powder biscuit," or by some similar name, is the result. An interesting variety of bread made without leavening is known as "Maryland" or "beaten" biscuit. A rather stiff dough is made from flour and water, or milk, with shortening and salt added. It is kneaded and then beaten or pounded, being frequently turned over and over until it looks light and puffy. The biscuits are then formed and baked. The folding and pounding of the dough incloses small quantities of air in numberless little blisters. These expand in baking and make the biscuit light and porous. The different kinds of bread from other grains than wheat, as "corn bread," "brown bread," "rye bread," "gems," etc., which are made in many households, vary somewhat in different regions, but they all follow the same principles which govern the bread making from wheat flour—that is, the flour or meal is mixed to a dough with water or milk, and some leavening substance is generally added to make the dough porous. Eggs, sugar, and shortening may be added, and sometimes spices, chopped nuts, or raisins mixed in, so that the varieties of bread become numerous.

UNLEAVENED BREADS.

The most interesting of these is perhaps the Passover bread, which has been used during Passover week by orthodox Jews from the time of Moses until now. It is simply a mixture of flour and water, baked in round cakes until it is dry and hard, and is not unlike plain water crackers. Pilot bread, or ship's biscuit, is another simple preparation of flour and water so cooked that it can be kept for any length of time. Crackers, or biscuits, as they are often called, especially in England, are also a variety, or, more correctly, numerous varieties of unleavened breads. Milk, butter, lard, spices, dried fruits—anything or everything desired to give them a particular consistency, color, or flavor—is mixed with the flour and water, and the dough is then passed through ingenious cutting machines and quickly baked in a hot oven. Such crackers are dry and therefore a concentrated form of nourishment.

The original Graham bread, made without yeast from Graham meal according to the receipt of its inventor, and not to be confounded with raised Graham bread, is made by kneading the flour and water thoroughly and allowing the dough to stand several hours before baking. It is heavier than ordinary yeast bread, but still has a few "holes" in it, due probably to fermentation started by bacteria accidentally present in the flour or the air. It is sweet and by no means unpalatable, but probably the nutritive value of its protein is lower than Doctor Graham supposed.

So-called raw-wheat breads are on the market which are apparently made by pressing the clean and macerated grains into small cakes. Such foods, it is claimed, tend to counteract a tendency to constipation.

Gluten bread, as its name implies, contains the gluten of the flour from which more or less of the starch has been removed. To make it, strong flour and water are made into dough, which is pressed and strained under a stream of water until the starch has been worked out; it is then kneaded again and baked. It makes a light, elastic loaf, frequently prescribed for diabetic patients from whose diet it is considered desirable to exclude starch. Unfortunately not all the so-called "gluten flours" on the market have as much of the starch removed as their names or descriptions imply, and diabetics should be guided by the advice of an experienced physician or analyst in their choice of brands. Some of the diabetic foods now on the market have been recently studied at the Connecticut Agricultural Experiment Station and the analysis for true gluten flour given on page 13 was quoted from its report.[a]

Although macaroni, spaghetti, and other wheat pastes occupy a very different place in bills of fare, they are so similar to unleavened breads in their ingredients that they may fittingly be mentioned here. They are made by mixing hard wheat flour and hot water into a stiff paste, which is then molded and dried. The wheats most suitable for their manufacture, viz, the "durum" wheats, were formerly grown mainly in eastern and southern Russia, the Mediterranean countries, and South America, but recently they have been successfully cultivated in certain sections of the United States, so that domestic pastes are likely to become more and more common in the markets. Noodles, which are only slowly coming into general use in this country, though they have long been popular in Europe, differ from macaroni and the other flour-and-water pastes in having eggs mixed in, and are therefore lighter and richer in protein.

BAKING AND COOLING.

In the earliest days of bread making the dough was simply put into the ashes of the fire or on hot stones to bake; then came the ovens heated by a fire within, which are still used to some extent, and finally the elaborately constructed ovens which can be heated or cooled to any temperature by means of furnaces and ventilating devices around them. But whatever the structure of the oven, the changes which the bread undergoes while in it are essentially the same. It goes in a rather solid, uniform mass and comes out a light, porous body of increased volume with a crisp, dark exterior—the crust—and a firm, spongy interior—the crumb. Let us first see what happens in the crumb. This, of course, heats more slowly than the outside; indeed, the moisture which it contains prevents its temperature from rising much above the boiling point of water (212° F.). When first put into the oven the yeast continues working, but a temperature of 158° F. kills it. The gas in the dough, however, still expands, and, forcing its way outward, enlarges the loaf and gives it a spongy appearance. The gluten becomes stiffened by the heat, so that even after the gas in the bubble-like pores has escaped the walls still retain their shape. The starch granules and perhaps the protein compounds undergo certain chemical changes which are believed to render them more digestible. Meanwhile, the crust is becoming hard and dark; the heat changes its starch into stiff gum and sugar and dries out the moisture; the brown color is due to chemical changes known as "caramelization." The reason why bread made from bran-containing flours turns so dark during baking is not thoroughly understood, but recent French investigations indicate that it may be due to the action of enzyms on pigments present in the bran. Of course the proportion of crust to crumb varies with the size of the loaf. The accompanying table[a] gives the relative percentages by weight in loaves of different weight of German bread:

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[a] Connecticut State Sta. Rpt. 1906, Part II, pp. 153–165.

Comparative weight of crust and crumb in bread.

	Weight of loaf.	Crumb in loaf.	Crust in loaf.
	Grams.	*Per cent.*	*Per cent.*
Bread No. 1	398	55.2	44.8
Bread No. 2	880	59.7	40.3
Bread No. 3	1,783	64.3	35.7
Bread No. 4	1,998	71.2	28.8

The heat in the oven should not be too great, especially at first, or the outside of the bread will harden too quickly and the interior will not be done before the crust is thick and dark; further, the gas expanding in the crumb will be unable to escape through the crust and will lift up the latter, leaving great holes beneath it. To prevent too rapid formation of the crust, bakers sometimes moisten the tops of their loaves before putting them into the oven or have devices for passing steam over them during the baking. The steam also changes some of the starch into a sort of gum on the top of the loaf and gives it the shiny look so often seen in Vienna bread. The same effect can be produced by moistening the top of the loaf just before it is taken from the oven. Cooks sometimes get a similar result by spreading the top of the bread lightly with butter. If the oven is not equally heated throughout, a baker usually puts the small loaves into the hottest part at first, as the crumb of these bakes more quickly and is in less danger of being underdone. When these are baked, the larger loaves, whose crumb has baked gradually in the cooler parts, are moved into the warmer place and their crust is quickly hardened. In some large ovens the temperature is gradually raised during the baking; especially is this the case in the aerated bread factories. Aerated dough is mixed with cold water, and if it were immediately subjected to a high temperature the crust would form before the interior was more than warmed through. Accordingly, a peculiar oven is used for baking it, one end of which is heated much hotter than the other. Two cylinders, one at either end of the oven, are connected by an endless chain, on which the bread plates are hung; the dough is placed on the latter at the cooler end, and then is gradually swung over to the warmer end, the speed being regulated by the time needed for baking. This insures a thorough baking of the crumb, while the extreme heat at the last gives a good, crisp crust.

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[a] Arranged from Birnbaum's Das Brotbacken. Braunschweig, 1878, p. 255.

The temperature of an oven and the time required for baking depend upon the size of the loaves. Small biscuits or rolls can stand a much hotter oven and quicker baking than large loaves, which must be heated slowly and long. For ordinary purposes a baker heats the oven to 400° or 500° F. and lets a pound loaf bake an hour or an hour and a quarter; small rolls perhaps half an hour. An experienced cook can tell when the oven is hot enough by putting the hand in, but a pyrometer, as a thermometer for measuring high temperature is called, makes a much safer guide.

On being taken from the oven, bread should be placed on slats or sieves so that the air can circulate about it until it is thoroughly cooled. By that time all the gas and steam which are likely to escape have done so, and the bread may be put away. Some housekeepers wrap their hot bread in cloths, but this is not advisable, not only because it makes the bread "taste of the cloth," but also because it shuts the steam up in the loaf and makes it damp and clammy—an excellent medium for cultivating mold.

Of course, as great cleanliness should be observed in handling and marketing bread as in making it. Well-informed bakers appreciate this and many modern bakeries are models of cleanliness. However, in some bakeries bread is kept where the dust and dirt from the street can get to it, or is delivered in dirty baskets or carts. In this way disease germs and dirt may easily lodge on its surface. Because the crust of fresh bread is so dry and hard molds and bacteria may not grow on it as easily as on a moister surface, but this does not greatly lessen the danger of dirty bread, which in most cases is eaten just as it comes from the shop. In Europe this danger is sometimes avoided by slipping the loaves into bags of parchment paper or something similar as soon as they are taken from the oven. Some American bakers adopt similar plans; a frequent one is that of wrapping the bread in paraffin paper or other special paper, which serves the double purpose of keeping out dirt and preventing the bread from drying.

STALE BREAD.

Good fresh bread has a crisp crust which breaks with a snap and an elastic crumb which springs back into shape after being pressed with the finger. Before bread is a day old, however, its texture has changed; its crust has become softer and tougher, while the inside seems dry and crumbly—the bread is "growing stale," as is said. This was formerly supposed to be due simply to the drying of the bread, but as the loss of water is found by experiment to be comparatively slight some other explanation is necessary. Various explanations have been offered, of which the most interesting seems that given by Boutroux in the work already quoted. He maintains that the apparent dryness is due to a shifting of the moisture from the crumb to the crust. When first taken from the oven the dry crust cools quickly, but the moist crumb retains its heat much longer. As gradually, however, its temperature falls to that of the surrounding atmosphere its moisture tends to distill outward, leaving a comparatively dry crumb and moist crust. Common experience shows that if stale bread is put into the oven for a few minutes it regains something of its fresh consistency—a crisp crust and moist crumb. This fact would be explained by the reverse of Professor Boutroux's proposition—that is, the moisture is driven back into the crumb. Such warmed-over bread lacks the elasticity of the fresh loaf, and its interior crumbles as easily as before it was reheated. Recent investigations indicate that this is due to chemical changes in the starch, which tends to go back into less soluble form as the bread grows old.

In this connection the well-known household plan of putting a piece of bread into the cake box to keep the cake moist may be mentioned. This end is accomplished probably because the bread gives off moisture more rapidly than the cake and keeps the air in the box too damp to allow the cake to lose much of its moisture. While cake thus kept does not dry as fast as it otherwise would, it loses its fresh taste, probably on account of chemical changes corresponding to those in aging bread.

CHARACTER OF BREAD AS RELATED TO THE GLUTEN OF THE FLOUR.

It has already been indicated that gluten is the ingredient of the flour on which its bread-making properties chiefly depend, and that gluten itself is not a simple protein compound, but contains two other compounds, glutenin and gliadin. In different kinds of flours not only does the proportion of gluten to the other ingredients differ, but also the proportion of glutenin to gliadin in the gluten itself. Two flours containing the same amounts of protein compounds when converted into bread by exactly the same process may yield bread of entirely different characteristics because of the different proportions of glutenin and gliadin in the two flours. The gliadin, a sort of plant gelatin, is the material which binds the flour particles together to form the dough, thus giving it tenacity and adhesiveness; and the glutenin is the material to which the gliadin adheres. If there is an excess of gliadin, the dough is soft and sticky, while if there is a deficiency, it lacks the power of expanding. Many flours containing a large amount of gluten and total proteid material and possessing a high nutritive value do not yield bread of the best quality because of an imperfect gliadin-glutenin ratio. This question is of much technical importance in the milling of wheat, especially in the blending of different types of wheat. At the Minnesota Experiment Station considerable study has been made of this and other problems regarding the bread-making properties of wheat, which may at least be mentioned here.

Some of the experiments referred to were planned to test the question whether it is the starch content or the gluten content that determines the bread-making quality of flour. In certain cases the proportion of starch in a normal flour was increased 10 to 20 per cent by the addition of wheat starch, while in others it was decreased to the same extent, and in still others 10 to 20 per cent of corn flour was added to the wheat flour. The breads made from the flours containing increased or decreased quantities of starch were then compared with that made from a like quantity of the normal flour. In the experiments in which the proportion of starch was increased by adding either wheat starch or corn flour there was practically no difference in either the size or the appearance of the loaf as compared with that from normal flour. The results of these tests, as well as of those made in other countries, clearly indicate that it is the gluten rather than the starch content that determines the bread-making properties of the flour.

To get other tests the proportion of starch was diminished, not by removing starch from normal flour, but by adding gluten to it. These tests emphasized the fact that it is not the starch content that determines the bread-making quality of the flour, and they also showed that an abnormally large amount of gluten does not yield a correspondingly large loaf.

Experiments were also made to determine the relation between the nature of the gluten and the character of the bread. This was done by comparing bread from normal flour with that from other flour of the same lot, from which part or all of its gliadin had been extracted. Dough made from the latter was not sticky, but felt like putty, and broke in the same way. The yeast caused the mass to expand a little when first placed in the oven; then the loaf broke apart at the top and decreased in size. When baked it was less than half the size of that from the same weight of normal flour, and decidedly inferior in other respects. It was about as heavy as the same quantity of rubber. The removal of part of the gliadin produced nearly the same effect as the extraction of the whole of it, and even when an equal quantity of normal flour was mixed with that from which part of the gliadin had been extracted the bread was only slightly improved.

Some experiments have recently been made at the Ontario Agriculture College [a] to determine what kinds of flours were best adapted to making milk biscuit with baking powder, and the conclusion reached that soft flours, i. e., those in which the gluten was not too strong, made biscuits that were tenderer and more easily handled than strong flours.

LOSSES OF MATERIAL IN BREAD MAKING.

In whatever way bread is made there is always some loss of materials in the process beyond that of the flour and dough accidentally lost in the mixing and molding, and these losses are especially noticeable in bread made with yeast. In experiments carried on at the Minnesota and New Jersey Agricultural Experiment Stations it has been estimated that anywhere from 1.5 to 8 per cent of the nutrients in the flour may disappear in this way. The yeast plants require a certain amount of nitrogenous material for their growth, but fortunately feed to some extent on the amid compounds, substances of less nutritive value than protein, and thus occasion only slight loss of valuable food material. A small proportion of the fats also disappear, probably volatilized by the heat of baking. The greatest loss occurs in the carbohydrates. It has been seen that during the process of fermentation part of the starch is changed to carbon dioxid and alcohol; in the later stages small amounts of volatile acids are also formed from the decomposition of carbohydrates. In tests in which care was taken to prevent loss the equivalent of 1.68 per cent of the carbohydrates was lost in this way. When bread is less carefully made the loss is likely to be much greater.

Of course part of these losses are inevitable, and the superior lightness, flavor, and keeping qualities of well-made yeast bread more than compensate for them. Evidently the art of producing a well-raised and at the same time the most nutritious loaf depends on letting the fermentation continue just long enough to avoid sogginess and heaviness, and no further.

IMPERFECTIONS IN BREAD.

The heaviness or sogginess such as was just referred to is one of the common and most undesirable faults in bread. As has been pointed out, it may be caused by the use of flours whose gluten is too weak to absorb the water put into all the dough, or, to state it in another way, by the use of too much water in proportion to the flour; by too little or by too poor yeast; or by insufficient kneading, rising, or baking. Heavy bread is popularly considered to be very productive of digestive disturbances. When chewed it rolls itself into solid lumps, which might readily hinder the action of the saliva and gastric juices.

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[a] Ann. Rpt. Ontario Agr. Col. and Expt. Farm, 34 (1908), pp. 242–247.

Occasionally the crumb of fresh bread breaks when cut, instead of separating cleanly under the knife. According to Jago,[a] harsh, dry flours, not sufficiently fermented, may be the cause of this, or the dough may have lost its tenacity by being overworked.

Another common fault in bread is a crumb full of large, irregular holes instead of the small, even pores which it should show. These occur in overkneaded or overraised dough; or, if they are found just below the crust, they mean that the oven was too hot and that the crust formed before the carbon dioxid had finished expanding.

Sometimes bread makers are troubled by what is known as "sticky" or "slimy" bread. In such cases bread three or four days old takes on a light-brown color and a peculiar taste and odor. Gradually, too, it becomes sticky or slimy until it may be pulled into strings, sometimes several feet in length. The trouble appears to be caused by the common potato bacillus (*Bacillus mesentericus vulgatus*), a minute organism which finds its way into the materials of the dough, survives the baking, and, growing in the bread, causes it to decompose. Experiments made at the Wisconsin Experiment Station[b] show that the bacilli enter the bread with the yeast, which in the cases investigated was a variety of the compressed yeasts ordinarily on the market. It was also proved that the bacilli will survive the heat of baking. Accordingly, if yeasts are not carefully made such trouble may occur at any time, but especially when the weather is warm and favorable to the growth of the bacilli. The best safeguards are to keep the bread in a cool place and to bake only as much as can be consumed within a day or two.

Not infrequently, especially in damp weather, mold forms on the outside, or even in the inside of bread. Mold, like yeast, is a minute plant whose spores (or seeds) are floating about everywhere in the air, ready to settle down and grow wherever they find a moist, suitable home for themselves. The best practical way to protect bread from them is to keep it in a dry, air-tight box.

But all these faults seem insignificant compared to that dread of all housekeepers and bakers, sour bread. This is due to lactic, or, in the worst cases, butyric, acid given off in the growth of undesirable bacteria which accidentally find their way into the dough from the air, the water, or in some other way. A little acid is not necessarily harmful, as was seen in the discussion of bread made with leaven and barm; but when the acidity is very pronounced or even accompanied by putrefaction (developed in company with butyric acid) then something is radically wrong. Possibly the vessels in which the bread was made were not thoroughly cleaned after the last using and some of the undesirable bacteria got into the dough from them; or perhaps the yeast contained an undue proportion of these bacteria; or, if the latter were found only in normal quantities, possibly the yeast itself was weak and was quickly exhausted. The trouble may be due to the fact that the dough was allowed to stand too long after mixing, the yeast ceased working, and the dangerous bacteria which grow best in the presence of acetic acid, such as occurs after alcoholic fermentation has ceased, had gotten the upper hand. If none of these things are at fault, the undesirable bacteria may have come from the flour itself. Such troubles are, fortunately, very rare, and if bakers and housekeepers guard against all the other dangers they are reasonably certain to make sweet bread. If bread grows sour with age, it has probably caught the undesirable bacteria from the air, just as it catches mold. Very rarely, however, bread perfectly sweet at first grows sour before the bacteria in the air have had a chance to get at it. The only possible explanation for this is that the bacteria have managed to survive the baking and are growing luxuriantly in undisputed possession of the good things in the bread. Soda is often used by housekeepers in bread to prevent souring, and in small quantities does not injure the flavor of the bread. In breads made from special flours which contain no true gluten—oatmeal, barley, etc.—it is convenient in the production of a sweet, well-raised loaf.

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[a] The Science and Art of Breadmaking, William Jago. London, 1895.

[b] Wisconsin Sta. Rpt. 1898, p. 110.

Besides the acid-producing bacteria, various others sometimes occur in bread, mostly harmless, but some of them very curious in their effects. Most striking among these is the *Micrococcus prodigiosus,* a minute organism which makes blood-red spots in the dough and whose presence gave rise to many interesting superstitions during the middle ages.

NUTRITIVE VALUE AND COST OF BREAD.

In order to decide which of several foods furnishes the most actual nourishment for a given cost, it is necessary to know not only the actual price and the nutritive ingredients of each, but also their relative digestibility. The one which is found to furnish the greatest amount of digestible nutrients for a given sum will be the cheapest, provided both are equally wholesome and desirable otherwise.

CHEMICAL COMPOSITION.

The chemical composition of the finished loaf differs somewhat from that of the original ingredients, but depends primarily upon that of the flour from which it is made. If milk and butter (or lard) are used in mixing the dough, as is commonly the case, their nutrients are, of course, added to those of the flour; but when only water and flour are used the nutrients of the bread are simply those of the flour. In either case, however, the proportions of the nutrients in the bread are smaller than those in the flour, because a considerable part of the moisture from the water or the milk used in mixing the dough is present in the bread after baking; that is, a pound of the bread would contain less of any of the nutrients than a pound of the flour, because the proportion of water in the bread is greater. The following table, which gives the results of analyses of patent wheat flour and several sorts of bread made from it, illustrates this point:

Composition of flour and of bread made from it in different ways.

Materials.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Flour	10.11	12.47	0.86	76.09	0.47
Bread from flour and water	36.12	9.46	.40	53.70	.32
Bread from flour, water, and lard	37.70	9.27	1.02	51.70	.31
Bread from flour and skim milk	36.02	10.57	.48	52.63	.30

The increase of water in the bread hardly needs explanation, since it is evidently due to the water added in making the dough. The decrease in protein and carbohydrates is in part only apparent and is due to the increased proportion of water, but is in part real, as was explained on page 33. It has been estimated that the alcohol generated by the yeast plant is equivalent to about 1 per cent of the total weight of the bread. Earlier investigators reported a small percentage of alcohol (less than 0.5 per cent) in the bread, but according to Snyder's investigations no appreciable amount of the alcohol remains after baking. Part of the starch in the crust has been changed into dextrin, and that in the crumb has become gelatinous or partly soluble. The gluten, as has previously been pointed out, has taken definite shape. This really means that it has coagulated very much as the white of an egg does in boiling. The increase of fat in bread made with lard is of course due to the latter ingredient and the increase of protein in skim-milk bread of course comes from the protein in the milk.

It is apparent that two kinds of bread from the same lot of flour may differ according to the method used in making the bread. On the other hand, two loaves of bread made by exactly the same process, but from different lots of flour of the same grade or brand, do not necessarily have the same composition, because of a possible variation in the flours. The chemical composition of wheat is not a fixed characteristic, different kinds of wheat varying widely in this respect. Furthermore, the composition of the same sort of wheat varies with several factors, such as climate, rainfall, and the soil in which it is grown. It is evident, therefore, that general statements regarding the composition of flour and bread can hardly be universally accurate.

Since durum wheat has become a common crop in many regions of the United States much interest has been manifested regarding the value of durum flour for bread making and other household purposes. As is the case with other types of wheat, the quality varies in different cultural varieties. The many analyses which have been reported show that on an average durum wheat and the flours made from it do not differ materially from similar products of other wheats. For instance, in an extended comparison made by the Bureau of Plant Industry [a] it was found that the durum wheat flours tested showed, on an average, 12.61 per cent protein, and Northwestern spring wheat flours 13.01 per cent, the range in the two cases being much the same, and further, from studies of the proportion of gluten and of gluten constituents in durum flour, the conclusion was reached that on an average it did not materially differ in these respects from flour from other varieties of wheat.

The results of numerous bread-making tests at agricultural experiment stations and elsewhere indicate that bread of good quality and appearance may be made from durum flour, and judging by data gathered by the North Dakota Agricultural Experiment Station,[b] housewives who are familiar with the use of durum flour consider it satisfactory for bread making and other household purposes.

In color, durum flours from different varieties of wheat show a wide range, some flours being white and others rather dark. It seems fair to say that in general it is yellower than flour from the varieties more commonly milled.

COMPOSITION OF BREADS AS COMPARED WITH SOME OTHER FOODS.

To show the difference in the proportions of the different food ingredients in various foods, it may be well to compare the analyses of bread and other foods as given in the table on page 38. The samples of wheat bread here represented are grouped together according to the kinds of flour used; that is, all those given under Minnesota hard wheat were made in exactly the same way from flours specially milled from the same lot of wheat, and the differences between them are due only to the differences in the milling processes. The Oregon and

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[a] U. S. Dept. Agr., Bureau of Plant Industry Bul. 70.

[b] North Dakota Sta. Spec. Bul. 19.

Oklahoma flours were likewise specially ground and the breads made in the same way as those from the Minnesota flours. Thus, if the figures for entire-wheat bread from these three classes of flours are compared, the differences may be accounted for entirely by differences in the original grain and not at all by differences in milling and baking. It should be remembered, however, that grains grown in the same locality may vary considerably in composition from year to year, so that the figures here quoted might not always be strictly accurate. They do, however, represent correctly the general differences between the breads from various types of wheat.

Composition of various sorts of bread and some other food materials.

Food material.	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Wheat bread:							
From hard Scotch Fife spring wheat, Minnesota—		*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per ct.*
Graham flour			47.20	7.76	1.27	42.82	0.95
Entire-wheat flour			49.16	7.45	1.14	41.73	.52
Standard patent flour			44.13	7.75	.90	46.90	.32
Second patent flour			42.10	7.75	.72	49.16	.27
First patent flour			44.40	7.48	.71	47.14	.27
From Oregon soft winter wheat—							
Graham flour			38.55	6.11	1.12	52.68	1.54
Entire-wheat flour			39.95	5.70	1.09	52.39	.87
Straight grade flour			34.95	5.41	.89	57.85	.90
From Oklahoma hard winter wheat—							
Graham flour			42.20	10.65	1.12	44.58	1.45
Entire-wheat flour			41.31	10.60	1.04	46.11	.94
Straight grade flour			37.65	10.13	.64	51.14	.44
Straight grade flour with 14 per cent bran			43.20	9.50	.84	45.55	.91
Straight grade flour with 7 per cent germ			38.00	11.07	1.13	49.12	.68
From miscellaneous flours—							
High grade patent			32.9	8.7	1.4	56.5	.5
Standard grade patent			34.1	9.0	1.3	54.9	.7
Medium grade patent			39.1	10.6	1.2	48.3	.9
Low grade patent			40.7	12.6	1.1	44.3	1.3
White bread, average	198		35.3	9.2	1.3	53.1	1.1
Rolls	20		35.7	8.9	1.8	52.1	1.5
Crackers	71		6.8	10.7	8.8	71.9	1.8
Macaroni	11		10.3	13.4	.9	74.1	1.3
Corn bread (johnnycake)	5		38.9	7.9	4.7	46.3	2.2
Rye bread	21		35.7	9.0	.6	53.2	1.5
Rye-and-wheat bread	1		35.3	11.9	.3	51.5	1.0
Beef, ribs:							
Edible portion	15		55.5	17.5	26.6		.9
As purchased	8	16.8	39.6	12.7	30.6		.6
Veal, leg:							
Edible portion	19		71.7	20.7	6.7		1.1
As purchased	18	11.7	63.4	18.3	5.8		1.0
Mutton, leg:							
Edible portion	15		63.2	18.7	17.5		1.0
As purchased	15	17.7	51.9	15.4	14.5		.8
Cod steaks:							
Edible portion	1		79.7	18.7	.5		1.2
As purchased	1	9.2	72.4	17.0	.5		1.0
Hens' eggs:							
Edible portion	60		73.7	13.4	10.5		1.0
As purchased		11.2	65.5	11.9	9.3		.9
Butter			11.0	1.0	85.0		3.0
Milk, whole			87.0	3.3	4.0	5.0	.7
Potatoes:							
Edible portion	136		78.3	2.2	.1	18.4	1.0
As purchased		20.0	62.6	1.8	.1	14.7	.8
Apples:							
Edible portion	29		84.6	.4	.5	14.2	.3
As purchased		25.0	63.3	.3	.3	10.8	.3
Chocolate, as purchased	2		5.9	12.9	48.7	30.3	2.2

From various dietary studies it is reckoned that the average man at moderately active work requires about a fifth of a pound of protein and so much of fats and of carbohydrates in his daily food that the available energy of all together will equal 3,500 calories. The more physical work he does the more food he will need. Milk contains the three classes of nutrients, but not in the proper proportion for adults in health. The large quantities of milk which a man would have to drink in order to obtain the necessary amount of nourishment make it inconvenient for exclusive use. Meats and cheese are rich in protein and fat. Vegetables are especially rich in carbohydrates. Bread contains both protein and carbohydrates, but in order to get the requisite amount of protein from it one would have to take more carbohydrates than is otherwise necessary. The combination of bread with such material as meat or cheese, which is rich in protein, makes a much better balanced ration.

Turning again to the bread analyses, it will be seen that while the breads made from graham, entire-wheat, and lower grade patent flours contain slightly more protein than the finer grades the difference is often extremely small, and differences between the composition of the original grains are more important. Thus graham flour made from Oregon soft winter wheat produced bread containing 0.7 per cent more protein than straight grade flour from the same grain; but straight grade flour from Oklahoma hard wheat yielded bread with almost two-thirds again as much protein as the Oregon graham flour. Evidently, then, the ordinary housekeeper who buys flour under a brand name which tells little or nothing of its origin is about as likely to get a high percentage of protein in a patent as in a graham or an entire-wheat flour. Fortunately the differences are likely to be very small in any case.

In considering the differences in the composition of bread made from various flours, it should not be forgotten that the amount of water which a loaf contains affects the percentage of nutrients present. The quality of its gluten allows Oklahoma hard-wheat flour to absorb and retain more moisture in bread made from it than Oregon soft wheat, for instance, and the percentage of protein and other nutrients contained in the former is proportionately smaller. Similarly, the percentage of protein and other nutrients in bread made from patent flours is relatively smaller than that in graham bread, because the former absorbs more water.

The figures given for the average composition of many samples of bread, rolls, crackers, and macaroni are interesting, because they represent better than the others, perhaps, the average of such goods as found in the open markets. The average composition of 198 samples of white bread is just about the average composition of the breads prepared from special flours in the first part of the table. The reason why crackers and macaroni seem to be richer in nutrients than bread is of course that they contain less water. Corn bread, like corn meal, contains less protein and more fat than wheat bread and flour. Of course the amount of fat in any kind of bread varies with the amount of shortening used. Judged by their composition, all breads are nutritious foods, and too great stress should not be laid on the variations in composition between the different kinds. So much popular discussion has been aroused in late years regarding the relative values of some of them, however, that a more detailed account of the matter may not be out of place here.

GRAHAM, ENTIRE WHEAT, AND STANDARD PATENT FLOURS.

The nutritive value of these three classes of flour and the breads made from them has been extensively investigated by Snyder at the Minnesota Agricultural Experiment Station and by Woods at the Maine Agricultural Experiment Station. Graham flour, strictly speaking, is simply wheat meal; that is, the entire grain ground to a powder. It has sometimes been made by removing the outer branny portions of the kernel and grinding this separately from the inner parts, afterwards combining the two, as it was thought that the efforts to grind the naturally coarse material with the rest of the wheat had a deleterious effect upon the bread-making qualities of the flour. It is now commonly made by crushing and grinding the whole of the kernel at once, without bolting or sifting. When thus prepared it contains the same ingredients as the wheat itself and in the same proportions. Even the most successful attempts at fine grinding, however, still leave it fairly coarse and with a large proportion of branny particles. To overcome this objection more or less bolting is frequently resorted to. Much of the flour sold as graham has been thus treated, though, of course, such a product is not really graham flour such as Graham advocated.

The term "whole wheat" or "entire wheat" seems rather inexact and suggests flour practically identical with the graham. The flour thus designated, however, is said to be made often by removing the branny outer covering and grinding the remainder. By such a method some of the outer portion of the wheat kernel would be retained in the flour. So far as can be learned much of the so-called whole-wheat flour is not so ground, but is made by mixing patent grade, middling, and low-grade flours with considerable of the germ. Whole-wheat flour is not so coarse as graham nor so fine as the white flours.

The flour most widely used is that known as straight patent, or standard patent, or family grade. Although this flour contains neither the germ nor the bran of the wheat, in modern exhaustive milling nearly 73 per cent of the kernel is recovered in it.

The following table gives the results of the analyses of flours and breads prepared from special lots of wheat at the Minnesota Experiment Station, and each group represents strictly comparable materials the differences in which are due only to differences in the process of milling and not at all to difference in the wheat used.

Composition of flours and breads as shown by experimental studies.

Material.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Minnesota wheat flour (fresh material):	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
First patent	10.55	11.08	1.15	76.85	0.37
Second patent	10.49	11.14	1.20	76.75	.42
First clear	10.13	13.74	2.20	73.13	.80
Standard patent	10.54	11.99	1.61	75.36	.50
Second clear	10.08	15.03	3.77	69.37	1.75
"Red dog"	9.17	18.98	7.00	61.37	3.48
Entire wheat	10.81	12.26	2.24	73.67	1.02
Graham	8.61	12.65	2.44	74.58	1.72
Oregon wheat flour (fresh material):					
Standard patent	8.94	7.55	1.25	81.82	.44
Entire wheat	8.66	8.25	1.67	80.35	1.07
Graham	8.15	8.97	1.68	79.48	1.72
Oklahoma wheat flour (fresh material):					
Standard patent	9.93	15.06	.92	73.57	.52
Entire wheat	7.46	16.63	1.64	73.05	1.22
Graham	7.73	16.81	1.79	72.35	1.32
Bread made from patent flour (fresh material):					
High grade	32.9	8.7	1.4	56.5	.5
Standard grade	34.1	9.0	1.3	54.9	.7
Medium grade	39.1	10.6	1.2	48.3	.9
Low grade	40.7	12.6	1.1	44.3	1.3
Bread made from Oregon wheat flour (water-free basis):					
Standard patent	....	8.32	1.37	88.93	1.38
Entire wheat	....	9.49	1.82	87.24	1.45
Graham	....	9.94	1.83	85.72	2.51
Bread made from Oklahoma wheat flour (water-free basis):					
Standard patent	....	16.24	1.02	82.03	.71
Entire wheat	....	18.06	1.77	78.75	1.60
Graham	....	18.43	1.94	77.12	2.51

Comparing the three grades of flour from the same lot of wheat, it will be noticed that in each case the proportion of protein was largest in the graham and smallest in the standard patent flour, the entire wheat being between these two. On the other hand, the proportion of carbohydrates was smallest in the graham and largest in the standard patent flour.

The breads from the different flours, made in such ways as to afford comparison, bear the same relation to one another as the flours in respect to the proportions of nutrients. Thus, in the breads made from different grades of patent flour, that from the high-grade flour, which had the lowest protein content, had the least protein, while that from low-grade flour, which is the richest in protein, had the most. This is true of the breads of which the analyses are given in the table, even though the proportion of water is highest in the bread from the low-grade flour; if the computations were based upon the dry matter of the breads the differences would be still larger. In the case of breads made from the different grades of Oregon and Oklahoma wheat the values given are for dry matter, in order that the comparison may be absolute. These data show that in each case the graham bread had the most protein and the least carbohydrates, as was the case with the flours. Considering that these two nutrients are not present in flour in proper proportions for a well-balanced diet, there being an excess of carbohydrates and a deficiency of protein, it might seem from such a comparison of composition that the coarser flours would be the best. Before an adequate discussion of relative nutritive value is possible, however, the digestibility of the three flours must be determined.

DIGESTIBILITY OF DIFFERENT KINDS OF BREAD.

A knowledge of the digestibility of any food material is of prime importance, for two reasons: In the first place, unless a food is completely digested a portion of it does not serve the body as nutritive material, because only that part of the food which is digested and absorbed from the alimentary canal can be thus utilized; and, in the second place, some indigestible materials may act as irritants in the alimentary canal, and while they may stimulate the excretion of the digestive juices they sometimes increase peristalsis too much, thus hastening the contents along too rapidly to permit complete absorption, with the result that nutritive material which otherwise might be absorbed and serve to nourish the body is lost along with the indigestible materials. In estimating the nutritive value of a food material it is therefore necessary to consider not only its composition but also the proportions of its different nutrients that are digested and utilized.

The next question then is, What kind of bread furnishes the greatest amount of digestible nutrients? Among the earliest and most famous experiments made to test this question are those conducted by Meyer and Voit, of Munich, about thirty years ago. They used different kinds of rye and wheat bread, and reached the conclusion, which all later work has verified, that the digestibility of bread depends largely upon its lightness. The work done during ten years at the Maine and Minnesota experiment stations throws much light on the comparative value of different kinds of bread.[a]

Upward of 100 digestion experiments have been made with young, healthy men, with bread from different grades of flour ground from hard and soft wheats from Indiana, Michigan, Minnesota, Dakota, Oklahoma, and Oregon. In all these investigations great care was given to the securing of different grades of flour from the same lot of wheat, to the production of bread from the flours, and to all other details of the experiments, in order to secure uniformity of conditions, and thus insure fairness and reliability in comparison. The results of these experiments, therefore, give very definite information regarding the relative digestibility of bread from different grades of flour.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 85, 101, 126, 143, 156.

The larger number of these experiments were made with graham, entire wheat, and standard patent flours from wheats from different sections of the country. The averages of the results with these three grades of flour give the following as the proportions of nutrients that were digested from the different flours, these factors being commonly termed coefficients of digestibility: Standard patent flour, protein 88.6 per cent and carbohydrates 97.7 per cent; entire-wheat flour, protein 82 per cent and carbohydrates 93.5 per cent; graham flour, protein 74.9 per cent and carbohydrates 89.2 per cent.

The digestibility of the fat was also studied in some cases, but the quantity of fat in bread is too small to permit of accurate tests of its digestibility, and for the most part the results were believed to be inexact, and are therefore omitted. This is a matter of no importance, however, as bread is not considered as a source of fat in the diet. The very common custom of eating butter or some other fat with bread is in reality but a method of supplying this deficiency.

With all the subjects, and with all kinds of wheat thus far tested, the uniform result was that the digestibility of the standard patent flour was the highest, that of entire wheat the next, and that of graham the lowest.

The nutritive value of the mineral matters in the bran-containing flours has not yet been satisfactorily determined. Within a few years detailed research into the phosphorus compounds of flours, begun at the New York State Agricultural Experiment Station and later carried on in various laboratories, has revealed a new substance called phytin, which seems to have a distinct physiological action. Interesting and valuable as such work is, more studies are needed before the influence of these constituents of bran and of other parts of the wheat berry can be definitely understood. Probably too much stress should not in any case be laid on the importance of the extra amount of phosphates and other ash constituents of bran. It should be remembered that fine flour also contains such ash constituents, and it is not unlikely that they are in forms which are more available or useful than those in the bran, even if finely ground. These mineral substances are of undoubted value, but there are few experimental data to show the amount of different ash constituents necessary for maintaining the body in health. It is doubtless safe to say that the ordinary mixed diet of children and adults furnishes an abundance of mineral matter. A certain "bulkiness" in the diet is desirable, such as is supplied by the crude fiber of plants, and the coarser flours, owing to the particles of bran or some other property, often increase the peristaltic action of the intestine and thus tend to prevent constipation. They may at times otherwise aid digestion; hence for persons in need of a laxative, bread made from such flours may often be preferable to white flour, but for a healthy person its claim of superiority on the basis of nutritive value is hardly warranted at present. Certainly no plea can be made for them on the ground of economy, for entire-wheat and graham flours are not cheaper than white flour. On the other hand, it must not be forgotten that all flours are wholesome and palatable, and that variety in bread is just as pleasing as variety in meats, vegetables, and puddings. The housekeeper may therefore wisely use all the different kinds of flours here discussed to give variety to the diet and please the taste of different members of her family. As has been said, well-made bread of any kind is a very nutritious food, and the differences between the various kinds are too small to be of practical importance to persons of healthy digestions and comfortable circumstances.

Experiments similar to those with the flours just discussed have been made with different grades of patent flours. It was found that the percentages of digestibility differed very little, and that as far as nutritive value is concerned the cheaper grades are fully as good as the more expensive. The bread made from them is as light as that from the finer flours, but not quite so white and appetizing. Where rigid economy is necessary the cheaper grades can safely be used.

A number of experiments have also been made to study the effect of adding germ to patent flour. The digestible nutrients in the flour made with the germ, as found in these experiments, showed a trifle more protein and slightly less carbohydrates than in the flour without the germ. Therefore, practically no gain in nutritive value was obtained by retaining in the flour the germ that is ordinarily removed in the milling.

Crackers, macaroni, and various sweet cakes made from white flour have also been tested at the Minnesota Experiment Station, and it has been found that their digestibility was practically the same as that of white bread. Of course all these experiments were made with healthy normal persons, and the results should not be applied too closely to invalids or others of delicate digestion. Moreover, nothing very definite has yet been learned about the ease and quickness with which these foods are digested. Bearing these limitations in mind, however, it may safely be said that simple, well-made crackers and cakes, at least when eaten in moderate quantities, are digested by persons in health with much the same thoroughness as bread.

HOT, FRESH, AND TOASTED BREAD.

Statements of a popular nature are frequently met with regarding the unwholesomeness of hot bread. The fact that bread is hot has doubtless little to do with the matter. New bread, especially that from a large loaf, may be readily compressed into more or less solid masses, and it is possible that such bread would be much less finely masticated than crumbly, stale bread, and that, therefore, it might offer more resistance to the digestive juices of the stomach. However, when such hot bread as rolls, biscuit, or other forms is eaten in which the crust is very large in proportion to the crumb this objection has much less force. Little difficulty is then experienced in masticating the crumb, and it is doubtless usually finely divided. As far as is now known the changes ordinarily occurring in good bread as it ages do not affect its digestibility unless it becomes so dry as to be unappetizing.

When bread is toasted the chemical nature of some of its ingredients is changed and the carbohydrates at least become more soluble and presumably more easily digested. The ferments and bacteria which may have survived the baking or which have entered the bread later are also killed if the toasting is continued long enough; this may be of considerable advantage to persons of delicate digestion. Owing to its dryness, toast is more likely to be well masticated than fresh bread. These facts and the further one that perhaps owing to its crispness and greater flavor it is often more appetizing than bread explain why toast is so suitable for invalids. Of course its advantages are greater when it has been well toasted throughout than when only the outer surfaces have been subjected to the action of the heat.

PLACE OF BREAD IN THE DIET.

As previously pointed out, bread contains from 35 to 40 per cent of water. Since the remainder, about 60 per cent at least, is nutritive material, bread is really one of the most nutritious of the common foods, but few others equaling it in this respect. Bread supplies a large amount of carbohydrates, a moderate amount of protein, a small amount of mineral matter, and almost no fat. Since there is relatively an excess of carbohydrates and a deficiency of protein in wheat, bread could not serve alone for proper nutrition of the body, because an amount of bread sufficient to supply the requisite protein would furnish much more carbohydrates than necessary. In a mixed diet this discrepancy is of little importance, because the deficiency of protein is made up by such foods as meat or cheese. Bread and milk forms a much more suitable diet than bread alone. Where bread forms the whole or the main part of the diet, as it does among large numbers of the poor, the deficiency of protein is of much more consequence. Most methods of increasing the protein content of bread which have been suggested have a tendency to increase the cost of the bread too much. The use of skim milk instead of water for mixing the dough does not increase the cost of the bread very materially, but it does add appreciably to the protein content. A comparison of skim-milk bread with water bread made from the same flour, as given in the table on page 36, shows that the skim milk increased the protein about 2 per cent.

SUMMARY.

Cereals of one kind or another have always made an important item of human food, and of all the forms in which they have been used bread has proved the most satisfactory, palatable, and convenient. To prepare the grain for bread making it is usually cleaned, crushed, and sifted into a fine soft powder, which is called flour.

The nutritive value of bread depends not only on its chemical composition, but also on its digestibility, and digestibility in its turn seems to depend largely on the lightness of the loaf. It is the gluten in a dough which gives it the power of stretching and rising as the gas from the yeast expands within it, and hence of making a light loaf. Rye has less gluten proteids than wheat, while barley, oats, and maize have none, so that they do not make a light, porous loaf like wheat. It is possible that of the various kinds of wheat flour those containing a large part of the bran—entire-wheat and graham flours—furnish the body with more mineral matter than fine white flour; but it is not certain that the extra amount of mineral matter furnished is of the same value as that from the interior portion of the grain. They do not yield more digestible protein than the white flours, as was for a time supposed. It seems safe to say that, as far as is known, for a given amount of money, white flour yields the most actual nourishment with the various food ingredients in good proportion.

It should be remembered, however, that all kinds of bread are wholesome if of good quality, and the use of several kinds is an easy means of securing variety in the diet.

The raising or leavening of bread is usually brought about by letting yeast develop in it. These minute plants feed upon sugar in the dough and in their growth give off alcohol and carbon-dioxid gas, which (particularly the carbon dioxid), expanding with the heat, force their way through the dough and thus lighten it. In order to give the yeast a better chance to work, the dough is usually "set to rise" for some hours before it is put into the oven.

There are many methods of growing yeast at home or in the bakery, but the dry and the compressed yeasts now in the market seem to give equally good results with so much less labor that their use, in the United States at least, is becoming practically universal.

The lightness and sweetness of bread depend as much on the way in which it is made as on the materials used. The greatest care should be used in preparing and baking the dough and in cooking and keeping the finished bread. Though good housekeepers agree that light, well raised bread can readily be made with reasonable care and attention, heavy, badly raised bread is unfortunately very common. Such bread is not palatable and is generally considered to be unwholesome, and probably more indigestion has been caused by it than by all other badly cooked foods.

As compared with most meats and vegetables, bread has practically no waste and is very completely digested. It is usually too poor in protein to be fittingly used as the sole article of diet, but when eaten with due quantities of other foods it is invaluable, and well deserves its title of "the staff of life."

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Issued April 18, 1910.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 390.

PHEASANT RAISING IN THE UNITED STATES.

BY

HENRY OLDYS,

Assistant, Biological Survey.

WITH A CHAPTER ON

DISEASES OF PHEASANTS.

BY

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Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., January 18, 1910.

Sir: I have the honor to submit herewith and to recommend for publication as a Farmers' Bulletin a report on Pheasant Raising in the United States, by Henry Oldys, assistant in the Biological Survey. The propagation of pheasants is a comparatively new industry in the United States, but it has grown rapidly in the past few years, and by proper management may be made profitable. A steadily growing demand for pheasants insures a ready market for all that can be raised. The present bulletin, prepared in response to numerous inquiries for information on the subject, is designed to present a clear and concise account of the methods used by successful pheasant raisers. To add to its practical value, a chapter on the diseases to which pheasants are subject has been contributed by Dr. George Byron Morse, of the Bureau of Animal Industry.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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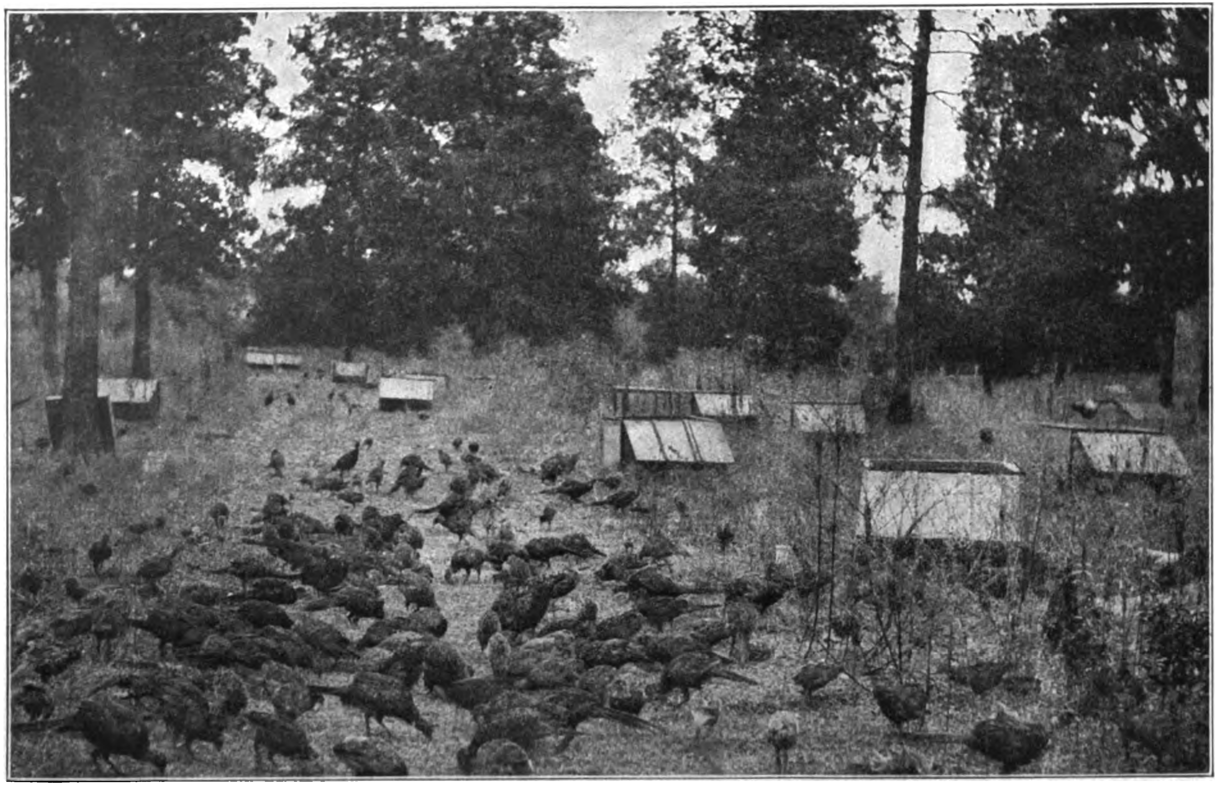

Fig. 1.—Pheasants feeding—state game farm near Springfield, Ill. (From photograph furnished by the state game commissioner.)

PHEASANT RAISING IN THE UNITED STATES.

INTRODUCTION.

Within recent years a new industry, the rearing of pheasants, has begun to engage attention in the United States, and propagating ventures, ranging from the single pen with one or two pairs of birds to the pheasantry of many acres and thousands of birds, are scattered throughout the country. Some of these experiments have been conducted by the States through their game officials; others by associations and individuals. In a few cases large expense has been incurred and great care and attention have been bestowed on the experiments. Efforts have been made also to stock numerous public and private parks, preserves, and aviaries. To supply the demand, not only have pheasants been imported from the Old World, but many persons in this country have undertaken to rear them. In view of the widespread and rapidly increasing interest in the subject, the Department of Agriculture has made a special investigation of the methods of pheasant raising. The results are here condensed in the form of practical suggestions for the benefit of those interested in the industry.

SPECIES OF PHEASANTS.

A few words as to different kinds of pheasants are essential to a proper understanding of the subject of pheasant propagation.

The ringneck pheasant (*Phasianus torquatus*), usually imported from China, its natural home, has a broad white ring about the neck. It is variously called ringneck pheasant, Chinese pheasant, China pheasant, China torquatus pheasant, Chinese ringneck, Mongolian pheasant, Denny pheasant, and Oregon pheasant (fig. 2).[a]

The English pheasant (*Phasianus colchicus*) has no ring about the neck. It is imported from Europe, but in comparatively small numbers, and is known as the English pheasant, dark-necked pheasant, and Hungarian pheasant (fig. 3).

---

[a] Present knowledge indicates that the ringneck really comprises several species and subspecies that have been included under a single name, but in the absence of a final decision of the matter the name will here be used as referring to a single species.

The English ringneck pheasant (*Phasianus colchicus* × *torquatus*), a hybrid between the English and ringneck pheasants, has been brought from Europe in large numbers. It is generally correctly named, but is sometimes designated as English pheasant, ringneck pheasant, and even Mongolian pheasant. It often has more or less of the blood of the versicolor pheasant of Japan (*Phasianus versi-*

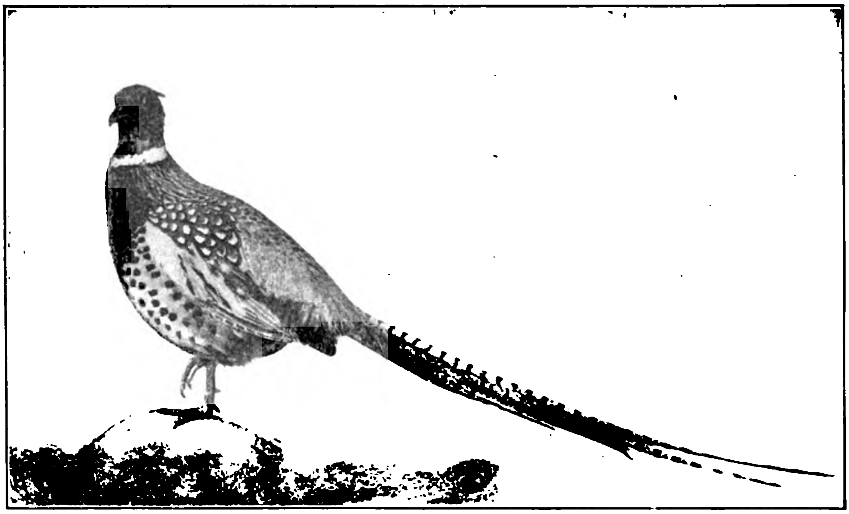

FIG. 2.—Ringneck pheasant (*Phasianus torquatus*). (From photograph of specimen in the U. S. National Museum mounted by Nelson R. Wood.)

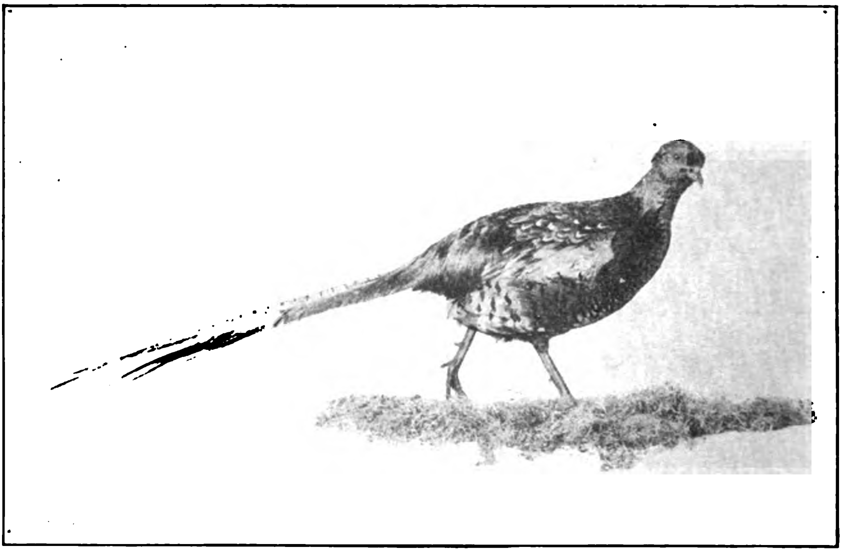

FIG. 3.—English pheasant (*Phasianus colchicus*). (From photograph of specimen in the U. S. National Museum mounted by Harry Denslow.)

color, fig. 11). In England both the English pheasant and the English ringneck are referred to as the common pheasant.

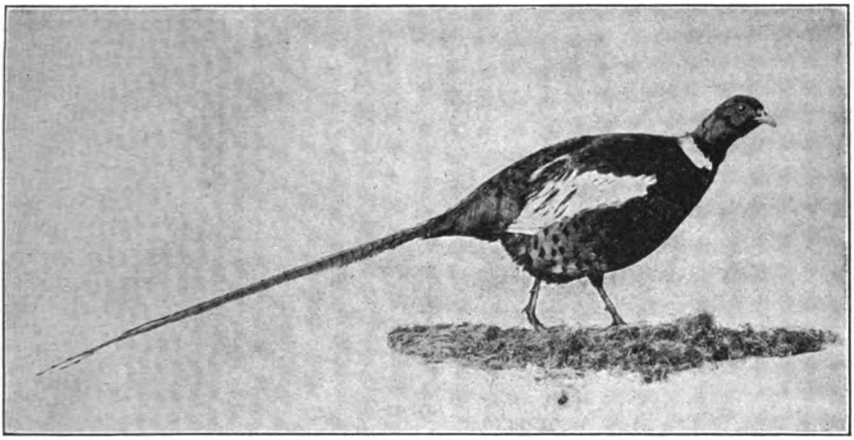

FIG. 4.—Mongolian pheasant (*Phasianus mongolicus*). (From photograph of specimen in the U. S. National Museum mounted by Harry Denslow.)

The Mongolian pheasant (*Phasianus mongolicus,* fig. 4), which has a more or less complete white ring about the neck, but in other respects resembles the English pheasant more than it does the ringneck, is the rarest of the four kinds in American preserves and aviaries. It is a native of the region about Lake Balkash, Central Asia.

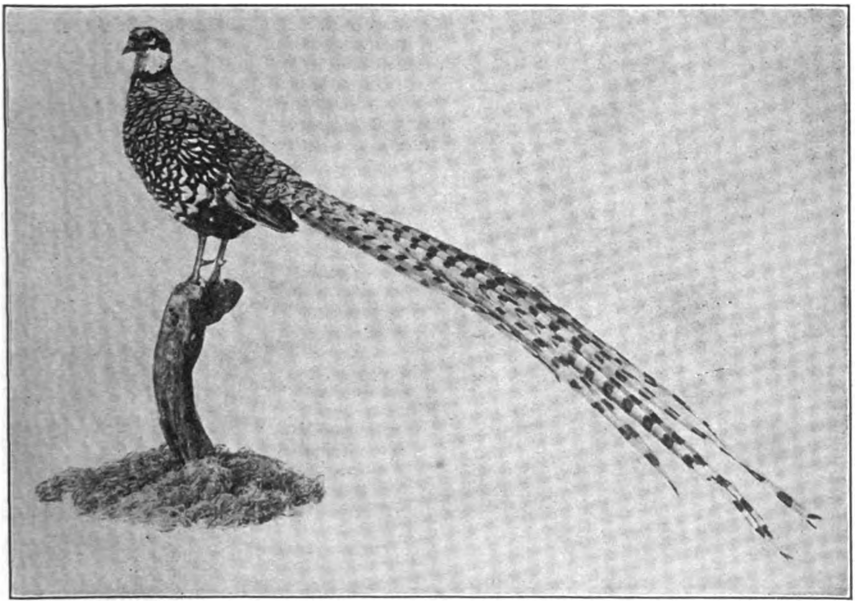

FIG. 5.—Reeves pheasant (*Phasianus reevesi*). (From photograph of specimen in the U. S. National Museum mounted by Nelson R. Wood.)

The Bohemian pheasant and the white pheasant are merely color phases, chiefly of the English pheasant and the English ringneck.

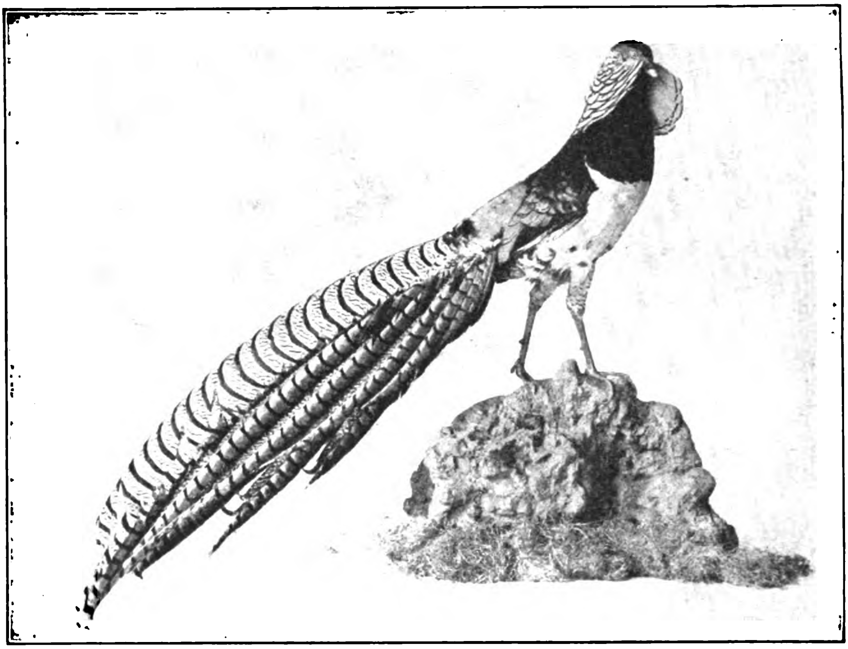

FIG. 6.—Lady Amherst pheasant (*Chrysolophus amherstiæ*). (From photograph of specimen in the U. S. National Museum mounted by Nelson R. Wood.)

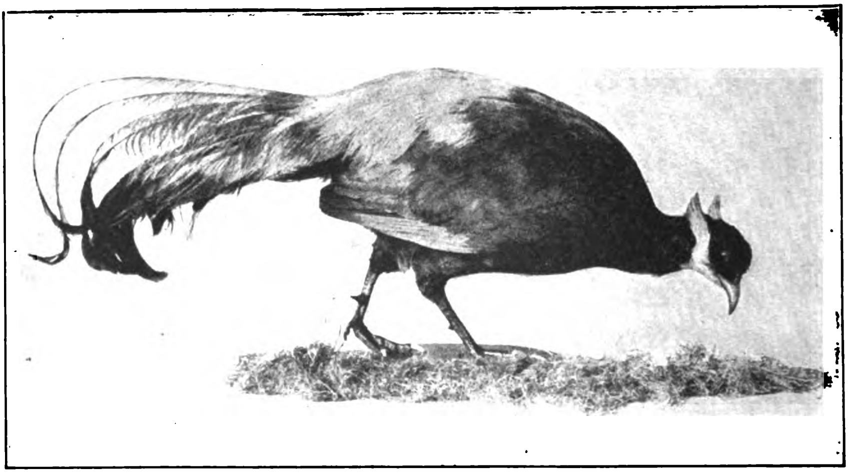

FIG. 7.—Manchurian pheasant (*Crossoptilon manchuricum*). (From photograph of specimen in the U. S. National Museum mounted by Nelson R. Wood.)

The Reeves pheasant (fig. 5), a large and striking bird with a tail sometimes 5 or 6 feet long, is usually met with in aviaries, though it has been placed in game coverts in Europe and, to a very limited extent, in the United States, and may still be found on certain Scotch estates, where it ranks very high as a game bird. It normally inhabits east central Asia.

Two of the best known and most commonly imported pheasants are the golden and Lady Amherst (fig. 6), both of the genus *Chrysolophus*, originally from the mountains of eastern Tibet and western and southern China. Both are favorite aviary birds, and the golden pheasant has been liberated in various game covers in America and Europe, but with indifferent success.

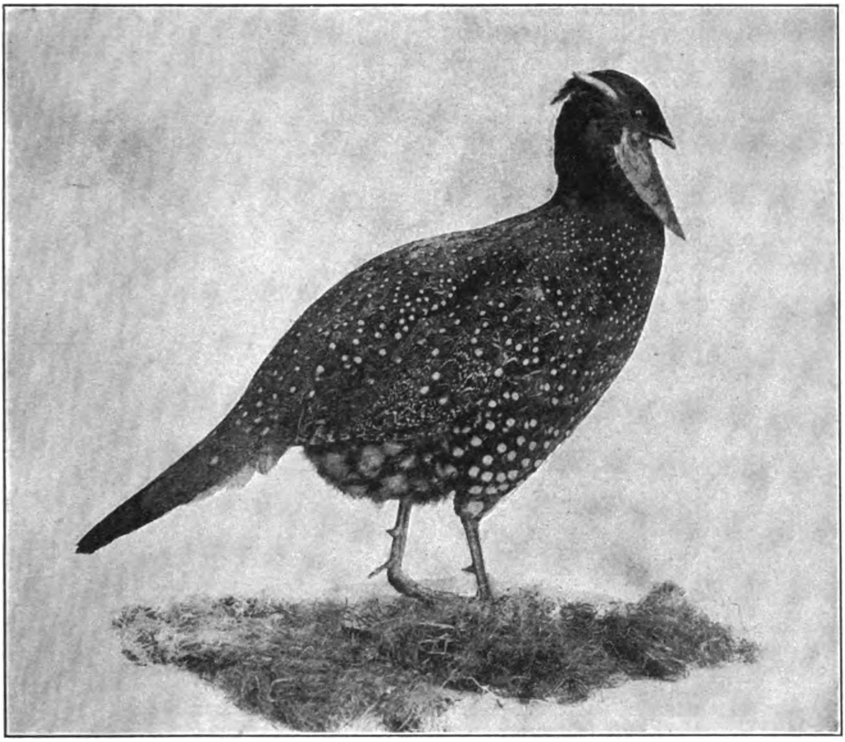

FIG. 8.—Crimson tragopan (*Tragopan satyra*). (From photograph of specimen in the U. S. National Museum mounted by Nelson R. Wood.)

The silver pheasant (*Gennæus nycthemerus*) is often seen in parks and aviaries, but the numerous other members of the genus, usually called kaleeges (or kalijes), are not often imported into this country. The home of the genus is the Indo-Chinese countries and the lower ranges of the Himalayas.

The eared pheasants (*Crossoptilon*), large, dull-colored birds of the higher ranges of central and eastern Asia, are known in American aviaries mainly through the Manchurian pheasant (fig. 7), the most northerly member of the genus. These pheasants lack the timidity so characteristic of most of the pheasant family and would probably lend themselves readily to domestication. At present their high price—$40 to $60 a pair—is practically prohibitive of any extensive attempt to domesticate them, but should they become more common, they would be excellent subjects for such experiments.

Other aviary pheasants are the horned pheasants (*Tragopan*, fig. 8), large, brilliantly plumaged birds, whose ranges extend from the Himalayas to central China; the firebacks (*Lophura*), likewise large, bright-feathered birds, from the Shan States, Cochin China, and the southern islands from Sumatra to Borneo; the peacock pheasants (*Polyplectron*), from the same general region; the monauls (*Lophophorus*, fig. 9), from the wooded heights of the Himalayas, the best known of which is the gorgeously iridescent impeyan pheasant; the Argus pheasants (*Argusianus*), the most expensive of all the pheasants and rarely imported from their home in Siam and islands to the southward; the blood pheasants (*Ithaginis*), from the high mountains of eastern Tibet, northern India, and western China; the koklass pheasants (*Pucrasia*), mountain birds of northern Afghanistan, eastern Tibet, China, and Manchuria; and finally the jungle fowls (*Gallus*), whose home is in the extreme south of Asia and islands to the south-

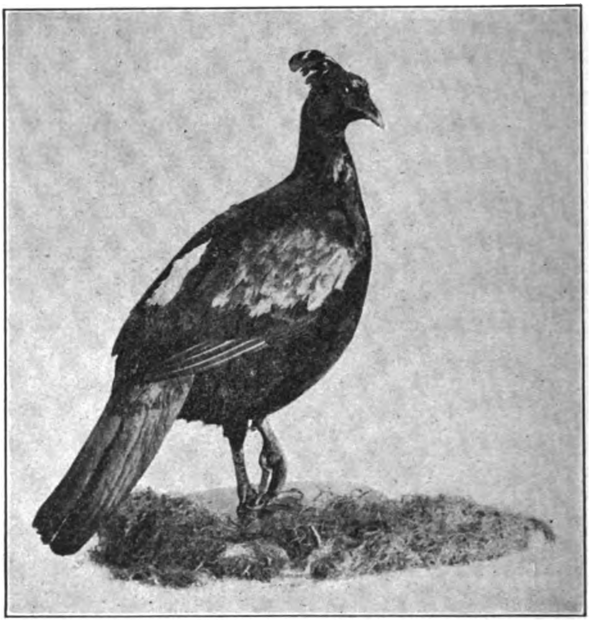

FIG. 9.—Monaul (*Lophophorus refulgens*). (From photograph of specimen in the U. S. National Museum mounted by Harry Denslow. The light area on the wing is due to reflected light from its iridescent feathers.)

ward, and whose general appearance strikingly supports the belief that they are the birds from which our domesticated chickens are derived (fig. 10).

HISTORY OF PHEASANT RAISING.

EUROPE.

The English pheasant (*Phasianus colchicus*) derives its specific name from the ancient country of Colchis, on the eastern shore of the Black Sea. It was imported thence into Europe by the Greeks, probably under Alexander the Great, and was by them reared for food. Perhaps at the same time, but probably one or two centuries later, it was brought from the adjoining country of Media to Egypt, where it was reared in the palace at Alexandria and was highly esteemed as a dainty for the table. Its propagation in confinement was continued in the days of the Roman Empire, under which it appears to have been carried throughout much of Europe and as far west as Britain. It was introduced into Ireland and Scotland before the close of the sixteenth century, and has recently been established in Sweden and Norway. It is now acclimatized practically all over Europe, and has been introduced into the United States, Canada, Australia, and New Zealand.

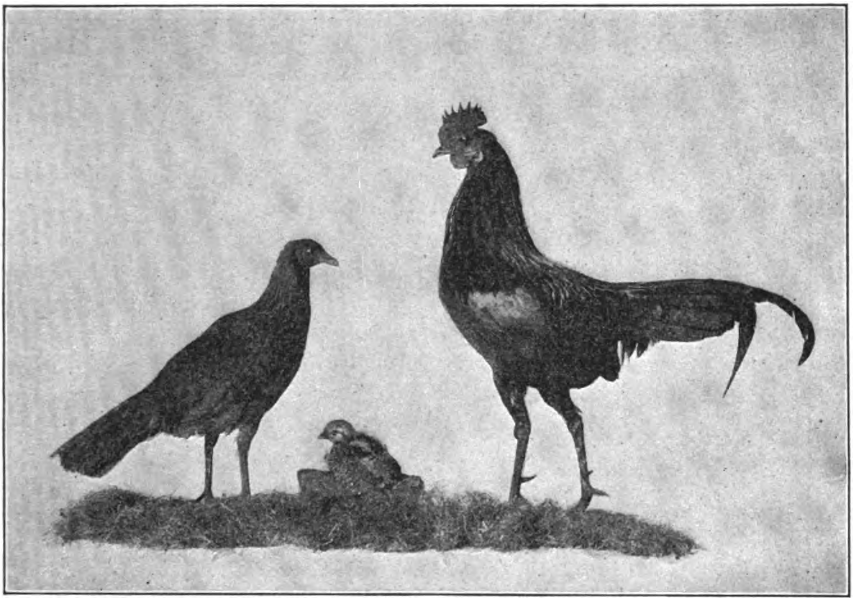

FIG. 10.—Red jungle fowl (*Gallus bankiva*). (From photograph of specimens in the U. S. National Museum mounted by Nelson R. Wood.)

The pheasant was doubtless reared in English preserves from the time of its introduction, but the earliest actual evidence of its propagation is the record of the employment of a pheasant breeder for Henry VIII in 1502. At the present day the number propagated in confinement in England greatly exceeds the number breeding there in a wild or semiwild state. The comparatively recent introduction into Great Britain of the German custom of pheasant driving, which consists of shooting pheasants driven by beaters over the shooters, or 'guns,' has given great impetus to pheasant raising during the past century, and the pheasant preserve is now a common adjunct of the English estate.

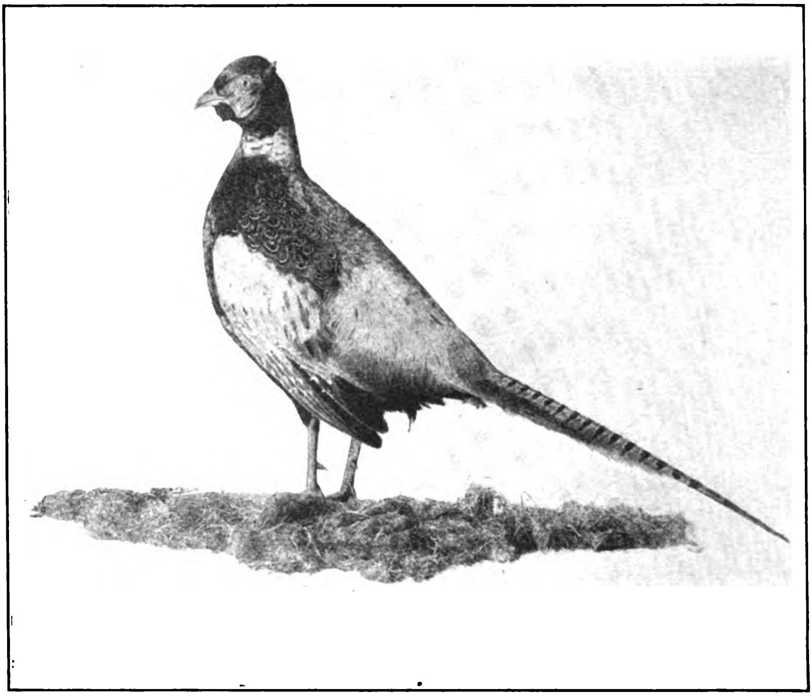

FIG. 11.—Versicolor pheasant (*Phasianus versicolor*). (From photograph of specimen in the U. S. National Museum mounted by Nelson R. Wood.)

This stock, however, is nearly all of mixed blood. A little more than a hundred years ago the ringneck pheasant (*Phasianus torquatus*) was introduced into England and crossed with the English pheasant, then the only pheasant in British coverts. And about the middle of the last century the Japanese versicolor pheasant (*Phasianus versicolor*, fig. 11) was introduced for crossing with the hybrid English ringneck. Both species interbreed freely with the English pheasant and with each other, and the hybrids are perfectly fertile. In each case the first effect of the crossing was a decided improvement of the stock, due doubtless to the introduction of new blood. As a result hybridizing became so popular that now, outside of Norfolk, where the original stock has to some extent been retained unmixed, pure birds of any one of the three species are rare in England. Other crosses also have been made, but only here and there, and without the same general intermixture of type as a result.[a]

UNITED STATES.

Efforts to acclimatize pheasants in the United States are of comparatively recent origin, though earlier than is popularly supposed. More than a hundred years ago, Richard Bache, an Englishman who married the only daughter of Benjamin Franklin, imported from England both pheasants and partridges, which he liberated on his estate in New Jersey, on the Delaware River near where the town of Beverly now stands. But although he provided both shelter and food for them, the birds had all disappeared by the following spring.

A second attempt was made early in the nineteenth century by the owner of a New Jersey estate situated between the Hackensack meadows and the Passaic River, opposite Belleville. A park was fenced and stocked with deer and English pheasants, but despite feeding and careful protection these birds likewise disappeared during the winter.[b]

Nearly eighty years ago, a writer in the Turf Register stated that Robert Oliver of Harewood, near Baltimore, Md., had for many years imported foreign game, including not less than 100 English pheasants. These increased rapidly and were in time turned out, some at Hampton, some at Brookland Wood, and a large number at Harewood. Those liberated at Hampton and Brookland Wood bred, and were occasionally seen afterwards, but those turned out at Harewood soon disappeared, the last being seen in 1827. In 1829–30, Mr. Oliver liberated at his estate at Oaklands, in Anne Arundel County, more than 20 pheasants of his own raising. On Mr. Oliver's death, his son Thomas continued the experiments, but they proved unsuccessful.[a]

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[a] Because of this intermingling of species, all pheasants imported as pure stock should be examined carefully. Even in English pheasants that appear to be pure bred (that is, which have no trace of a white neck ring), the subterminal bar of the ring-neck is usually more or less developed on the feathers of the lower back, and the basal part of the central tail feathers is rather widely barred with black, instead of showing the narrow bar of the pure-blooded English pheasant.—Ogilvie-Grant, Catalogue of Birds in the British Museum, XXII, 321, 1893.

[b] Forest and Stream, XXV, 103, Sept. 3, 1885.

These initial importations were followed by similar attempts to stock private preserves, but met with like failure. About thirty years ago, however, a successful effort was made to introduce the ringneck pheasant into Oregon, and since then acclimatization experiments have followed broader lines and have assumed greater importance. It will be convenient to consider these later ventures by states.

Oregon.—In 1880 Hon. O. N. Denny, then United States consul-general at Shanghai, shipped a lot of ringnecks to Oregon. All died on the way but 12 cocks and 3 hens, which were liberated 12 miles from Portland, near the mouth of the Willamette River.[b] The next year Judge Denny shipped another lot of ringnecks to Oregon, of which 28 (10 cocks and 18 hens) arrived safely at Portland and were liberated on the ranch of his brother, Mr. John Denny, in the Willamette Valley in Linn County.[c] These birds increased rapidly and spread until they became thoroughly established in the State. A shooting season of two and one-half months was opened in 1892, and 50,000 were reported to have been killed on the first day. In 1896, 10,000 were marketed in one month, nearly double the number of native grouse sold.[d]

The successful stocking of Oregon with ringneck pheasants at once aroused general interest in the United States, and requests for birds began to pour in. To meet the demands, numerous pheasantries were established in Oregon, and were soon doing a thriving business. The following list of shipments of pheasants from Oregon in 1899 indicates the widespread interest in the industry: Washington, 107; California, 187; Arizona, 2; New Mexico, 10; Idaho, 2; Montana, 9; Colorado, 73; Oklahoma, 2; Indian Territory, 6; Kansas, 3; Arkansas, 4; Missouri, 4; Iowa, 9; Illinois, 31; Indiana, 17; Ohio, 7; Tennessee, 12; Georgia, 12; Virginia, 6; Pennsylvania, 2; New Jersey, 2; and Massachusetts, 2; total, 509.[e] Orders for pheasants for even Alaska and Mexico have been filled from these Oregon pheasantries. Most of the efforts to transplant the bird have failed, owing chiefly to unsuitability of locality or improper methods of handling, but in the region of original introduction the ringneck is now a permanent addition to the game list. It is fairly well established in Oregon, Washington, and British Columbia.

Massachusetts.—In Massachusetts state pheasantries were established at Winchester and Sutton in 1894. The first year's experiment with a setting of English ringneck pheasant eggs was unproductive, and in 1895 a few ringnecks were obtained from Oregon. The account of succeeding years, as told in the annual reports of the Commission of Inland Fisheries and Game, is a record of patient endeavor to surmount obstacles—cold and wet seasons that diminished the vitality of eggs and chicks, various diseases, mistakes in feeding, destruction by rats, deterioration of stock through inbreeding. These and minor difficulties marked one of the most thorough, capable, and untiring attempts to raise and liberate pheasants under state auspices made in this country. In 1906 an epidemic of cholera occurred at Sutton, and only 75 birds were raised from 1,200 eggs. Despite these numerous and dispiriting setbacks, several thousand pheasants have been liberated, and through these efforts and those of private individuals the State now contains a moderate stock in its covers. In November, 1906, more than 3,000 pheasants were killed in Massachusetts in the open season of one month. The game commission is now devoting its propagation experiments mainly to the restoration of native game, as more likely to yield satisfactory results than pheasant introduction.

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[a] Turf Register, II, 227, Jan., 1831; III, 79, Oct., 1831.

[b] Annual Report Department Agric. for 1888, p. 485, 1889.

[c] Report of Fish and Game Protector of Oregon for 1895-96, p. 85, and letter from Hon. O. N. Denny, quoted in report of Massachusetts Fish and Game Commission for 1894, p. 17, 1895.

[d] Report of Fish and Game Protector of Oregon for 1895–96, p. 89, 1896.

[e] Rept. of Game and Forestry Warden of Oregon for 1899–1900, pp. 7–8, 1901.

Ohio.—Ohio records a similar experience. The game commission began in 1892 with English ringneck pheasants and their eggs. In 1895 it undertook the propagation of ringnecks, of which it raised several hundred in a hatchery established at Celina. Twelve ringnecks were placed on Rattlesnake Island, near Put-in-Bay, to breed in the wild state. Later a pheasantry was established at London, where operations were for a while very successful. In 1900, from 161 hens 7,075 eggs were obtained, of which 4,500 were set, and 2,575 distributed in the State. From the 4,500 eggs 3,181 chicks were hatched. Of those reaching maturity 2,239 were distributed, some being placed in every county in the State, and 418 were carried over to the next breeding season. During this year a three-week season was opened, but so great was public interest in the experiment that few took advantage of the opportunity to shoot the birds. On March 17, 1901, 38 cocks and 228 hens were placed in the breeding pens. The number of eggs collected was 9,041, of which 5,000 were set and 4,000 distributed (in 66 counties). At the pheasantry 3,420 chicks were hatched, of which 2,852 were reared. The distribution of adult birds was 1,688 (in 88 counties). In July, cholera made its appearance at the pheasantry, and before it was under control killed 1,124 birds. The following year the experiment was abandoned, as the impression prevailed that for climatic and other reasons pheasant raising could never produce satisfactory results in Ohio, and the legislature failed to provide the necessary funds. The game commission had reported that pheasant rearing involved large expense and that, despite the utmost care, disease was likely to sweep away a large part of the hatch. They stated that in their opinion better results could be attained by rearing quail. Pheasants in considerable numbers are still to be found in the game covers of Ohio, but they are likely to die out unless replenished with fresh stock.

New York.—In 1897 New York raised 40 ringnecks from a stock of 12 birds at its hatchery at Pleasant Valley. In 1898 its stock had increased to 180, and in 1899 more than 400 were raised; in 1900, 230 were hatched; in 1902 the stock was 520, of which 199 were liberated; and in 1903 it was 534, of which 225 were liberated. In 1904 cold and rainy weather reduced the stock to 448 and the experiment, although popular and successful, was abandoned as unprofitable, owing to the readiness with which pheasants could be procured from commercial hatcheries. Meantime the efforts of the game commission were being supplemented by propagation and liberation of pheasants by individual pheasant raisers. Hon. W. A. Wadsworth, of Geneseo, in particular, liberated a large number of pheasants in the Genesee Valley. In 1904 he turned out 350, one and a half times as many as were distributed by the game commission in that year. The total distribution of pheasants by the game commission, covering the period from 1898 to 1904, and embracing 47 counties, was 1,191, of which the average cost was $12.50 per pair. Eggs were distributed to the number of 484; but this method of stocking the State was not deemed desirable and after one distribution was practically discontinued. At present many pheasants are being raised on private preserves in the State, particularly in the Adirondacks, on Long Island, and in the Genesee Valley, and the legislature of New York has recently passed a measure providing for the establishment of a state game preserve, where pheasant propagation will be resumed.

Indiana.—Indiana liberated about 700 English ringnecks and ringnecks in the period from 1897 to 1902. A pheasantry was established at Madison in 1903 and, as usual, promised to be very successful, but it failed and was abandoned in 1906. At present the state game commissioner is trying the experiment of establishing numerous preserves of 4,000 to 10,000 acres each throughout the State by contracts with farmers. Imported pheasants and partridges purchased for the purpose are liberated on these preserves, and the farmers agree to allow no hunting thereon for four years after stocking. These birds are fed and cared for, but are allowed to propagate naturally. More than a hundred such preserves have been established within the last three years, with 40 to 100 game birds on each, mainly, however, Hungarian partridges, which the commissioner believes to be better adapted to the purpose than pheasants. The object of this course is to provide numerous refuges where the birds may increase and from which they may spread so as to stock the State. The movement is popular with both farmers and sportsmen and has thus far proved successful. The number of pheasants in the State at present is estimated by the commissioner at 6,000 to 8,000.

Illinois.—In 1891 a pair of ringnecks (the first, it is claimed, to cross the Rocky Mountains) was brought from Oregon by a citizen of Illinois and liberated at his home. This initial importation was followed by others, the total number shipped in the eleven years from 1896 to 1906, inclusive, being 135. Pheasants of various other species also were introduced, but all these attempts to stock the State were futile. The establishment of the resident-hunting-license system later produced a very large revenue, and it was decided to undertake pheasant propagation and introduction on a broader scale than had yet been tried anywhere in the United States. In the spring of 1905 a state game farm (fig. 1) was established on a tract of 400 acres, and here the work of pheasant raising was begun under the personal supervision of the state game commissioner. The main stock is English ringneck pheasants, though other species—ringneck, versicolor, English, and Mongolian—have been used in breeding experiments. The game farm has not been an unqualified success. An outbreak of roup in 1907 carried off thousands of the young of that year, and other obstacles have been encountered. In 1908, 20,000 eggs were distributed among the farmers of Illinois, while 15,000 chicks were hatched on the game farm. The extensive scale of this experiment gives it special interest, but it is too early yet to pronounce on results.

California.—In California the ringneck was introduced by private enterprise in 1894. In 1897 the board of fish commissioners began purchasing pheasants from Oregon, and from 1897 to 1900 bought and liberated 416 ringnecks and 153 English ringnecks. The commissioners subsequently abandoned the attempt to stock the State by this method, and have recently established a state game farm at Haywards. They are, however, devoting their efforts mainly to Hungarian partridges. They report that pheasants are being propagated in a small way by people in all parts of the State, and that there are probably a few breeding wild in the State, particularly in Santa Clara, Santa Cruz, Fresno, Humboldt, and Kern counties.

New Jersey.—New Jersey was one of the first States in which interest in the importation and propagation of pheasants was aroused, and several private preserves in the northern part of the State attest the continuance of this interest to the present time. About ten or fifteen years ago the state game commission bought and liberated a considerable number of ringnecks, which did well at first but soon began to decrease and in three or four years had disappeared. In 1904 the commission established a small preserve at Oradell and for a year or two undertook the propagation of pheasants on a small scale. The commission had in mind about this time the plan later adopted by Indiana of forming preserves by agreement with owners of contiguous farms, but does not seem ever to have put it into practical operation. Nevertheless, within the past six years more than 2,000 pheasants have been distributed throughout the State, mainly in trios of one cock and two hens. Thus far the experiment has proved successful.

Vermont.—In Vermont more than 1,200 English ringneck pheasants were turned out in 1892 from Shelburne Farms, a private preserve, and later the Vermont Fish and Game League liberated a number of ringnecks. In 1902 the game commission reported that the latter attempt had failed, but that pheasants were yet to be found along the shores of Lake Champlain; these were, however, being exterminated by gunners.

Pennsylvania.—In Pennsylvania apparently no attempt has been made to stock the State with pheasants; but as early as 1871 a pheasantry with 30 birds was started at Blooming Grove Park, a large private preserve in Pike County. Since then the propagation of pheasants has been continued, the surplus each year (3,000 in 1904) being liberated in the preserve for shooting by the members of the association owning it. Other preserves have since been established in the State on which pheasantries are conducted and small stocks of birds maintained.

Other States.—In Utah ringnecks liberated in Salt Lake County from a private preserve about 1895 were reported in 1906 as doing exceptionally well. In New Hampshire the game commissioner liberated a few English ringnecks and ringnecks in 1896, but apparently without lasting result. The Minnesota game commission started a pheasant propagation plant in 1905, and liberated a few birds, but on account of great mortality among the chicks little has been accomplished. The commission is still experimenting, but reports that it can buy pheasants more cheaply than it can raise them. Delaware, in 1903 and 1904, liberated 88 pairs of pheasants, which have practically disappeared. Kansas has liberated, since 1906, more than 3,000 ringnecks and English ringnecks, which are at present reported to be multiplying. In the past few years a propagating company has turned out a large number of pheasants in Colorado with results yet to be determined.

Private preserves.—In addition to these more noteworthy attempts to introduce pheasants into different States, many private preserves have been stocked with pheasants in the last thirty years, while to supply the demand for birds, numbers of individuals in this country have undertaken to propagate pheasants in confinement.

It is difficult to transplant pheasants to a new region without considerable care in feeding them and protecting them from enemies. Occasionally, as in the case of the ringneck pheasant in western Oregon, an exotic species finds the new conditions suited to its requirements and thrives, but such instances are comparatively rare. In rearing birds in confinement, however, success is less dependent on the character of the region than on individual experience and capacity. Most of the commercial pheasantries established in the United States and Canada have been comparatively short-lived, but some have succeeded and have proved an important source of revenue to their proprietors. The private preserves have been, as a rule, fairly successful. On some, English gamekeepers and English methods are employed; others are American in character, though borrowing largely from the long experience of England and other countries of Europe.

PHEASANTS IN FIELD AND COVERT.

The failure of many efforts to add pheasants to our fauna is largely due to insufficient knowledge of their habits and the character of their normal environment. It is useless to undertake to acclimatize a bird in a region differing widely in climatic and other physical conditions from those to which it has been accustomed. Thus, an attempt to introduce into one of the prairie States the common blood pheasant (*Ithaginis cruentus*), which inhabits the Himalayas at from 10,000 to 14,000 feet elevation, would result in failure.

It must be remembered, also, that introduced birds have to adapt themselves to a new flora and fauna, and that this is often a slow process and frequently fails. If liberated in the wilds, they must be provided with reserve food and shelter until able to care for themselves, which may take several years. In Oregon the ringnecks put out came at first regularly to farmyards to feed with the domestic fowls; and English ringnecks liberated on Grand Island, Michigan, were driven back by severe weather to the pens from which they had been allowed to escape a few months before.

If pheasants are imported for stocking preserves, suitable coverts should be prepared for them. In their native country pheasants frequent the margins of woods, coming into open tracts in search of food and retreating into thick undergrowth when alarmed. An ideal pheasant country is one containing small groves with underbrush and high grass between the trees, thorny hedges, berry-growing shrubs, water overgrown with reeds, and occasional pastures, meadows, and cultivated grainfields. Bleak mountains, dry sandy wastes, and thick woods are not frequented by pheasants normally; nor do they seek pines, except for protection. A small grove of mixed evergreen and deciduous trees on the southern slope of a hill furnishes favorable shelter.

On the preserve additional shelter should be provided in winter. Rude huts or even stacks of straw will serve. Suitable food should be planted—such as buckwheat, millet, corn, cabbages, and turnips. Stacks of unthreshed grain or of beans may be placed about the preserve.

When shooting is permitted, it is not wise to shoot only the cocks. If all the hens are spared, they will increase out of proper proportion, to the detriment of both quantity and quality of the progeny. Very old cocks and hens should be destroyed. Old cocks are inferior for breeding purposes, and old hens will frequently beat off 2- and 3-year-old hens and prevent their mating.

If the birds are annually caught up for breeding, it is important to remember that continued rearing in confinement tends to decrease of vitality and other changes that impair the value of a game bird. The Massachusetts Game Commission, after ten or twelve years' experience, found that their stock deteriorated, becoming smaller and more variable in markings and showing a lower vitality in both eggs and chicks. An infusion of wild blood, especially of another species, will temporarily correct this tendency; though the experience of the last hundred years in England seems to indicate that hybrids eventually reach a grade inferior to that of either parent. Hybrids between the English pheasant and the ringneck, and later between this hybrid and the versicolor pheasant, were at first greatly sought, but at the present day the pure-blooded birds of these three species are more highly valued than the composite birds.

GAME PHEASANTS.

There is not much difference between the pure versicolor, ringneck, and English pheasants, as regards value in the field or on the table, though the Japanese bird is smaller than either of the other two, a trifle wilder, a more potent breeder, and possibly less disposed to stray; while ringneck hens are perhaps more prolific than those of the other species.

The Mongolian pheasant (*Phasianus mongolicus*), a large, hardy, handsome bird, may prove of value in game preserves. Pure stock of this species is maintained by Hon. Walter Rothschild in his pheasantry at Tring, Herts, England. The cross between this pheasant and the ringneck is reported as both larger and handsomer than the ringneck, and also a bolder flyer; but we should hesitate to regard this improvement of stock as permanent. The Prince of Wales pheasant (*Phasianus principalis*), recently introduced into England from Afghanistan, and since imported to a slight extent into the United States, is greatly praised by those who have tried it. The handsome Hagenbeck pheasant (*Phasianus hagenbecki*) from the Kobdo Valley in northwestern Mongolia (the most northerly point occupied by any member of the pheasant family) is strongly recommended by W. B. Tegetmeier, a leading English authority, on account of its large size, handsome plumage, and fine edible qualities; and the Reeves pheasant (fig. 5), in the few places where it has been tried, has proved very desirable. Many species of true pheasants (*Phasianus*) have not yet been tested in Europe or America, but probably each in a suitable region would prove satisfactory to both sportsmen and epicures.

As regards the pheasants of other genera, usually seen only in aviaries and zoological collections, some would be of little value in game preserves. Thus the Manchurian eared pheasant (fig. 7), a large and heavy bird from the mountains of Manchuria and northern China, is too tame and apathetic for the game fields. The silver pheasant, a favorite aviary bird and one of the easiest to raise in captivity, is not a satisfactory game bird, as it runs too much before the dog, flies too low, and is rather inferior in flavor. In addition, its pugnacity makes it dangerous to other game birds. It is still found wild in limited numbers in northern Oregon, where it was introduced shortly after the successful introduction of the ringneck. The golden and Lady Amherst pheasants (fig. 6) have been introduced into game coverts, both here and in England, and the gorgeously feathered monaul (fig. 9) has received a limited trial in Wales. The better place for these birds is probably the aviary.

METHODS OF PROPAGATION.

OBTAINING STOCK.

A pheasantry may be started with mature birds or with eggs, the latter to be hatched by barnyard fowls. Many are tempted to begin with eggs because of smaller cost, but the uncertainties attendant on hatching the eggs and raising the young are such that it is probably cheaper to secure full-grown birds at the outset. If eggs are to be tried, they should be ordered in January or February, to be delivered in April or May. They should be placed under the hen as soon as possible.

Pheasants may be obtained from reputable dealers, of which there are a score or more in the United States and Canada, or they may be imported from Europe or Asia. If stock be imported, trouble may be saved by securing it through experienced and reliable bird importers, who are familiar with the business. A pen should be provided and supplied with food and water. On the arrival of the birds the crate should be placed in the pen, an opening should be made in the crate (preferably in the evening) sufficient to allow the birds to escape one at a time, and the attendant should withdraw, leaving the birds to find their way out alone. For the first few days they should be disturbed as little as possible.

PRICES.

The prices of pheasants vary with the season. They are lowest at the close of the breeding season and increase gradually until the next. They vary also according to the dealer; but so many things are to be considered, such as purity of stock, freedom from disease, care in shipment, and other details, that the lowest prices do not always mean the cheapest birds. English ringneck pheasants are least expensive—about $5 a pair. English pheasants and ringnecks (the pure-blooded birds) cost a little more; Reeves and versicolor pheasants, about $18 a pair; and Mongolian, $40. Of the more common aviary birds golden and silver pheasants are the cheapest, at about $12 per pair; next in price are the Lady Amherst and Reeves, which retail at about $18 or $20 a pair, while others range from this price up to $150 or $200 a pair. These prices are only approximate, and serve merely to give an idea of the relative values of the birds mentioned.

PENS.

Any well-drained ground is suitable for pheasant pens, but a gentle slope of sandy loam, comparatively cool in midsummer, furnishes ideal conditions. Clay is the poorest soil for the purpose, as it is likely to foster diseases. The pens should be provided with plenty of both sunshine and shade. They should be constructed of chicken wire, like ordinary poultry runs. Each pen should cover at least 100 square feet, more if possible; contracted quarters induce disease and afford their timid occupants too little protection from alarms. The pen should be from 6 to 8 feet high, and should be inclosed above with wire. If the pheasants are likely to be disturbed much, cord netting should be stretched 6 inches or more below the top wire, to prevent the birds from injuring themselves by flying violently against the top, as they are apt to do when frightened.

It is of course feasible to keep pheasants in a pen open at the top, by pinioning them or clipping their wings. But pinioning, besides disfiguring pheasants, disables them permanently. Birds that are to be liberated should never be pinioned, as it makes them useless for sport and a ready prey to natural enemies. Clipping is objectionable, owing to the necessity for frequent repetitions. Pheasants are timid and the less they are disturbed the better, especially when breeding. Furthermore, clipping is not always effective, as clipped pheasants sometimes climb up the sides of the pen and escape. Another objection to open-top runs is the danger of attacks by hawks and owls, particularly if the run can not be readily guarded. If a small open shed or inclosure be placed at one end (the upper), the birds will always have a dry dusting place, also a shelter in wet or stormy weather. The floor of this shed should be the natural earth, to furnish dust baths for the birds, and it should be raised slightly above the level of the run to avoid flooding. Dust baths are as necessary to pheasants as to poultry. They free them from lice and keep the plumage in good condition. Mortar, cinders (which birds seek with avidity), and plenty of grit should be kept in the shed. The sides of the run may be boarded if necessary to furnish seclusion, though it is usual to board them only at the base (fig. 12), and a few pheasant raisers regard even this as objectionable. The side wire should enter the ground for a foot and a half or two feet, to keep out burrowing animals.

It is very advantageous to have for alternate use an extra communicating pen alongside the one occupied. This affords opportunity to freshen the ground, grow grass, clover, or other cover, separate birds with objectionable traits, and in other ways add to convenience of handling and safety of stock. It has been found, too, that after hen pheasants have stopped laying in one pen they may be induced to resume by removal to another. One pheasant raiser reports that seven of his hens laid 131 eggs and then stopped; but when he put them into a fresh pen they laid 174 more. Perches should be supplied in the shed and also in the open pen. Pheasants usually spend the night in the open air in preference to the shed, even in winter. In their Asiatic homes, the English and ringneck pheasants are accustomed to severe cold weather in winter. They require protection from storms and dampness, rather than from low temperature, and they will frequently remain in the open runs during the roughest weather.

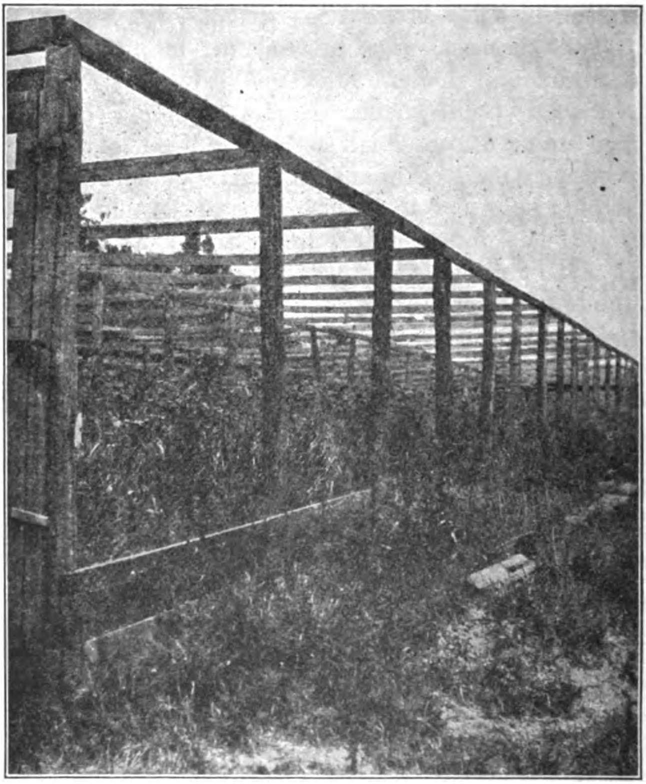

Fig. 12.—Breeding pen used on a Long Island shooting preserve. Boarded at base only. (Not in use at time photograph was taken.)

The pens and sheds should be kept scrupulously clean. There is no more fruitful source of disease among pheasants than uncleanliness. As has been aptly said, the pheasant pen should be kept as neat and clean as the front dooryard. Nevertheless chips and twigs may be scattered about to attract insects, and boughs for shelter should not be omitted. Each pen should be thoroughly spaded and limed every two or three years. Cover should be provided for the birds. The pens may be sown with clover, timothy, and other grass early enough to furnish ample cover by the time the birds are turned in. Small evergreens may be grown inside with decided advantage, or cut branches of evergreen or deciduous trees may be placed within. If growing grass or clover can not be conveniently provided in the pen, a piece of sod should be placed there occasionally. The birds enjoy tearing sod to pieces for the seeds, insects, and grass it contains.

PROTECTION FROM ENEMIES.

Careful protection must be provided against various enemies. Hawks, owls, crows, and other predatory birds, as well as cats and raccoons,[a] will be kept out if the top is covered. If traps and guns are used to protect pheasants from birds of prey, the destruction of mice-catching hawks and owls will result in serious losses through the unchecked increase of rodents. If the top of the pen is open, a foot of wire inclined outward and slightly downward should be extended from the top all around to prevent animals from scaling the sides. Burrowing animals may be frustrated by continuing the wire netting down into the ground, as already described. As an additional precaution it is a good plan to connect with the sides a strip of wire netting extending outward horizontally on the ground about a foot, as dogs, foxes, rats, and other burrowers try to dig close to the fence. Unbaited traps set alongside the pen will catch minks and other creatures that may be looking heedlessly for an opening. A lighted lantern on one of the posts at night will help to keep away minks. The old method of fastening a dog to a wire by means of a ring, which allows him to run along the wire for its full length, is still in use, and is an effective means of guarding the birds.

ATTENDANCE.

The pheasants should be attended, as far as possible, by the same person. It will even be well if the attendant always wears the same clothes when entering the pen, as pheasants are frightened by anything unfamiliar. English gamekeepers are accustomed to announce their approach by whistling as they near the birds, whether these are in pens or in the open. A former pheasant raiser states that she always tapped with a fork on the china feeding dish to call the young pheasants together at feeding time. If the pheasants are not intended for game covers, it will be found advantageous to tame them somewhat by gentle treatment. When care and consideration are shown and occasional delicacies are fed, they will respond and will readily learn to eat from the hand. Besides the pleasure this brings to the attendant, this course diminishes danger of losses through the birds dashing themselves in fright against the netting.

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[a] Two raccoons are said to have killed 150 young pheasants in one night on the Illinois State game farm.

EGG EATING AND FEATHER PLUCKING.

The need of plenty of room for penned pheasants can not be too strongly emphasized. Overcrowding, besides being conducive to disease, leads to the practices of egg eating and feather plucking. Egg eating is usually begun by cocks, though hens readily acquire the habit. Broken eggs left in the pens will almost certainly start it. The practice is more common in certain species, among them the Reeves and melanotte pheasants, than in others, while the versicolor seems to be free from it. If the pens are of ample size and the eggs are promptly and regularly removed, egg eating usually need not be feared. If begun, it should be checked at once. Various devices have been used to break up the practice, such as placing in the pen eggs of glass or wood, or eggshells filled with red pepper, soft soap, or other disagreeable substance. It is better, however, to remove the offender immediately to another pen, before the habit spreads. Feather plucking also requires immediate removal of the offender and of any badly plucked birds, which are likely to be objects of general attack, as otherwise serious damage to the other occupants of the pen may result. An abundance of room is preventive of both these faults. Cover should be provided for the hens in case the cocks are disposed to attack them. It may be necessary even to clip the wings of the cocks and furnish high perches for the hens to fly to for safety, or, better still, place in the pen a partition too high for the clipped cock to fly over.

FOOD.

Pheasants are small feeders, and there is greater danger of overfeeding than underfeeding. Overfeeding is productive of disease. In order to guard against it, the attendant should at first sprinkle a little food on the ground, wait for that to be eaten, and then repeat until the birds lose their eagerness, when feeding should be discontinued. The proper quantity of food for each pen may thus soon be ascertained. Pheasants are omnivorous, and as variety is advantageous, almost any edible substance may be fed—grain of all kinds, finely chopped meat, cooked cereals, table scraps, boiled potatoes, boiled rice, apples, turnips, rose hips, the tubers of Jerusalem artichokes, and finely chopped green food, as lettuce, grass, cabbage, onion tops, garlic, and chickweed. Green food is important and should be constantly supplied, even if it must be raised under glass. All green food must be chopped fine, as otherwise the birds are likely to become crop bound. Ground bone is excellent. Seeds of various weeds, when obtainable, may be furnished; hay seed also is good. Chestnuts, especially wormy ones, add to the variety. Grit should be supplied, as with chickens, and charcoal and cracked oyster shells are of great service. The food should not be thrown on the ground, but should be put into flat tin or enameled dishes, which after each feeding should be removed with every scrap of scattered food. The dishes should be scalded daily. Water should be furnished freely, but must not be allowed to become dirty or stale, or to remain in the sun. Sun-heated water often causes fatal diarrhea. A trough of running water in the pen (fig. 13) is excellent.

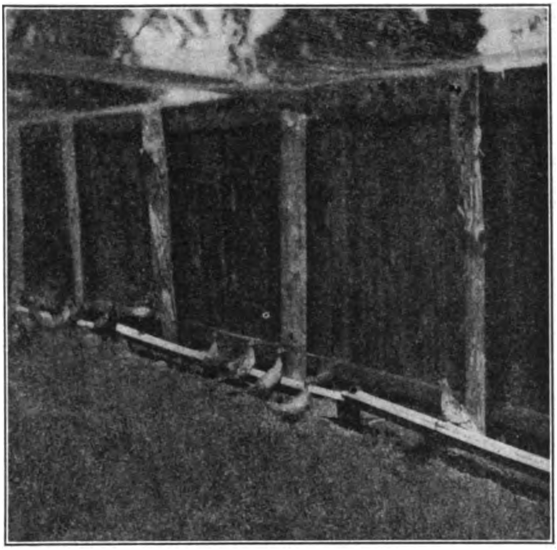

FIG. 13.—Side of breeding pen on a New Jersey preserve. Boarded at sides. The trough conveys running water from a cool mountain stream.

MATING.

The mating season usually begins in February and extends to June or July according to locality. As pheasants mate more readily if thoroughly accustomed to their surroundings, it is well to obtain stock in the fall. The birds should be placed in the breeding pens at least a month before the mating season. Most pheasants are polygamous,[a] and each pen should usually contain one cock to from three to five hens, though the number of hens with one versicolor cock may range up to 30, while silver, Swinhoe, and Sœmmerring pheasants breed in pairs. An extra number of cocks should be kept to replace any that die or are killed. In some pheasantries all the pheasants of one species are placed in one large pen (fig. 14), the proper proportion of cocks and hens being maintained, on the theory that while a smaller number of eggs results from this method, the chicks are stronger. But during the breeding season pheasant cocks are very pugnacious, and if not kept separate are apt to injure one another. Hence it is customary to have a small pen, not less than 9 by 18 feet or more than 30 by 30 feet, for each cock and his hens. Breeding pens should be on well-drained ground, and should have plenty of cover, to furnish retired places in which the hens may deposit their eggs. Shelter is not usually necessary for the birds, but a dusting place must be provided, and for this purpose a shed should be placed at the side of the pen from which storms usually come, or some other means provided by which a spot may be kept dry.

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[a] Evidence indicates that in its natural wild state the English pheasant is monogamous. In game coverts, however, even when allowed to breed wild, it has acquired the habit of polygamy, owing, it is supposed, to the overproportion of hens resulting from the great destruction of cocks.

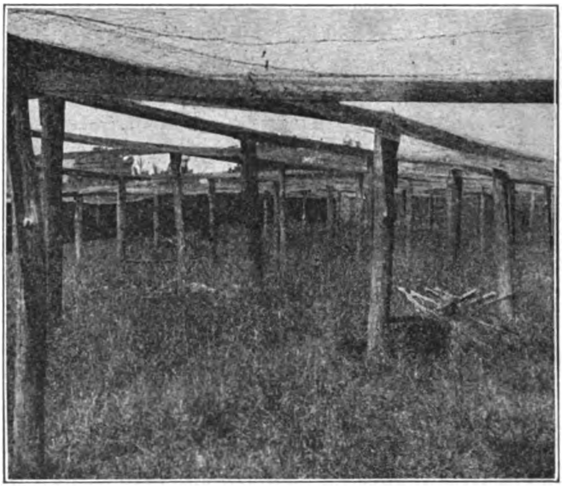

FIG. 14.—Breeding pen on a New Jersey preserve. Measures 100 feet by 200 feet, and accommodates 150 pheasants, which breed without separation. Note brush shelter provided.

The laying period varies somewhat with the species and locality. In northern New Jersey the ringneck, English, English ringneck, and Reeves begin about March 1 and continue to about the middle of July, and the golden and silver lay from April 1 to about the middle of June. No nest is required. The eggs should be gathered once or twice daily. They should be placed in bran as gathered, and should be set as soon as possible; but if it is not convenient to set them at once, they will remain in good condition for not more than two weeks in a covered box of fresh bran kept cool and dry; they should be turned daily. During the laying period the birds should have a plentiful supply of fresh gravel, old mortar, cinders, and ashes. Iron tonic in the water once a week is beneficial.

HATCHING.

Eggs should be hatched under barnyard hens unless it is convenient to procure turkeys, which are excellent for hatching and for brooding the chicks. Pheasant hens are broody but very wild, and the invariable experience has been that it is extremely difficult to secure satisfactory results by leaving them to hatch the eggs. Incubators may be employed, but the results are usually unsatisfactory. Bantams, especially Cochin bantams, are frequently used on account of their lightness. In the Royal Zoological Gardens of Antwerp, where pheasants are reared very successfully, half-bred Japanese silkies are used. Hybrids between Japanese silkies and ordinary game have been tried with good results. The silkies are small, light, and broody, while the game make excellent mothers, owing to their fighting qualities. Wyandottes and Rhode Island reds are very satisfactory. Some of the large and successful pheasantries of the United States use any hens that are light, clean-legged, and free from disease, as it is difficult to secure enough sitting hens when they are wanted. A few pheasantries raise their own hens, which is perhaps the better practice. In selecting a hen, it is essential that she be free from scaly leg, roup, and lice. Dipping the hen's legs in a 5 per cent solution of carbolic acid before placing her on the eggs, and repeating the treatment several times during the season, is a useful precaution against scaly leg. To guard against lice, which are very fatal to young pheasants, the hen should be dusted with insect powder before she is set and once a week thereafter, though not within three days of the hatching. In addition to this precaution the hen should have ready access to a good dust bath. The style and dimensions of the hatching box or coop may vary according to the judgment of the pheasant raiser, but the simpler it is the better. It should have no floor, but should be simply a cover for the nest, more for protection than for warmth. It should be well ventilated; a close, hot, stuffy hatching box will soon be infested with fleas and lice, which irritate the hens and injure the chicks. Impure air also lowers the vitality of the chick, even in the shell. The nest should consist of a sod placed grass side down on the ground and lined with a little short straw or grass. A 1-inch mesh wire or board run should extend in front of the coop for at least 2 or 3 feet, in which the hen may eat, drink, exercise, and dust herself at pleasure, and in which the chicks may run before they are removed to the rearing field. The run should be covered with ordinary poultry wire. A hinged top to the coop is convenient, as it gives ready access to the nest and eggs. Food and water may be placed in the run once a day. If natural dust can not be readily secured, ashes may be supplied. It is well to place other eggs under the hen for a day or two while she is shaping the nest, and thus avoid possible loss of pheasant eggs by breakage. If many settings are made, it will be found convenient to record the date of setting and the number of eggs to each hen. This may be done by marking the eggs or labeling the coops. On the ninth or tenth day the eggs may be examined and the fertile ones distributed so as perhaps to free one of the sitting hens for a fresh setting. If, however, only one or two broods are being raised, it is better not to disturb the hen by examining the eggs.

Nests should be kept clean. Broken eggs and all other refuse should be removed, and the remaining eggs washed, if soiled. The hen should, however, be disturbed as little as possible. When an egg has chipped but the chick is unable to break out in eight hours, it may be assisted by placing the egg in a shallow pan of water (at blood heat) for a minute or two, chipped part uppermost and out of the water, to avoid drowning the chick. The chick should never be drawn out of the shell by hand, but should be allowed to emerge naturally.

CARE OF YOUNG PHEASANTS.

The young should go without food for the first twenty-four hours after hatching, as during that time they derive all needed nourishment from the yolk, which they are then absorbing. Thereafter begins the most critical stage of pheasant life, and for two or three weeks watchful and unremitting care is necessary. Extreme cleanliness must be observed. Drinking and feeding vessels should be washed and scalded daily; weather conditions must be noted carefully, and every precaution taken to prevent exposure of the chicks to dampness or direct and excessive sun heat; the slightest disorder in the young must be treated promptly and decisively. In time of severe drought the grass near the coop should be sprinkled.

Some allow the chicks to remain in the hatching box and its run for three or four days before removal to the rearing field; others remove them at the end of twenty-four hours. Some use the same foster parent throughout; others, especially those rearing pheasants in large numbers, use separate hens for hatching and brooding, and make up broods of 15 to 20 by taking chicks indiscriminately from the hatching hens. In either event separate coops should be used for rearing and for hatching, and the rearing coop should be in its proper place in the field for a few days before it is to be occupied, in order to insure dryness of the ground beneath it. It is important to have clean sand or fine grit immediately available on removing the chicks to the rearing field.

The rearing field (fig. 15) may be in meadowland or in a garden or orchard according to convenience (a clover field is excellent); but it should be changed every year or two, in order to allow a restoration to normal abundance of its insect life, of which it will be largely depleted by the young pheasants. It should be large enough to permit the placing of the coops 30 yards or more apart, not only to give sufficient territory to each brood, but also to prevent the hens from killing chicks of other broods, as they sometimes do. If the rearing field is in grass or clover, paths 12 to 15 feet wide should connect the coops, and narrower paths at right angles to these are serviceable. These should be mowed and the cuttings removed before the chicks are placed in the field.

The rearing coop (figs. 16 and 17), which may be varied in style, should be provided with a wire run for the first three or four days, until the chicks learn the voice of their foster parent. A satisfactory type is one 2 feet square, with a sloping roof 2 feet high in front and somewhat less at the back. It is better to have it like the hatching coop, without a bottom, though, if necessary to keep out vermin, it may be floored with a fine mesh wire netting. It should be provided with a hinged shutter in front, or some similar device, to prevent the chicks from going out when the ground is wet, which is apt to result in cramp, a rapidly fatal and highly infectious disease. Proper ventilation must, however, be secured. The coop should be shifted daily to a fresh spot, except when the ground is wet.

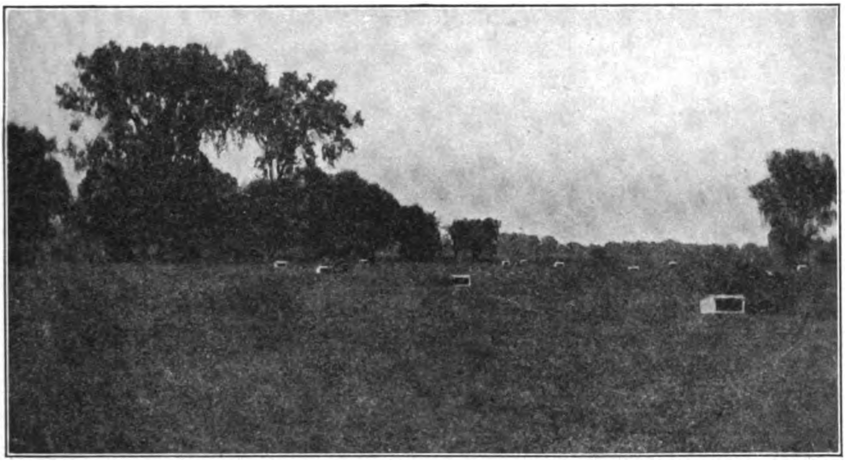

FIG. 15.—Rearing field on a pheasantry near Chicago, Ill. Note space between rows of coops.

Near each coop there should always be a leafy branch to furnish shelter and shade for the young. The runs may be retained throughout the rearing season if there is danger from hawks or crows, but in this event they should be as large as possible.

The hens may be kept cooped and the young allowed to run at large, in which case the front of the coop must be covered with a large mesh wire netting or bars; or both hens and chicks may be allowed the liberty of the field. In this, as in many other matters, choice depends on local conditions. Thus it might be advantageous to allow the young pheasants to run in a vegetable garden, which would be materially damaged if the hens were given the same privilege. It sometimes happens, too, that the hen when at liberty loses one or more of her brood. When possible, however, it is better to leave the hen free to go and come with the chicks.

While the young chicks require plenty of sunshine, it is important also that they be not exposed to the direct rays of the sun in very hot weather. They should not be given water that is not fresh and cool, and precaution should be taken that they do not drench or drown themselves in their drinking vessels. Shallow pans of water in which are placed stones the size of hickory nuts will avoid this danger.

FOOD OF YOUNG PHEASANTS.

Successful pheasant raisers agree that suitable food is most important in pheasant rearing, and each has his own formula. Certain general principles, which should always be kept in mind, are embodied in pheasant feeding. As with the old birds, it is better to err on the side of too little food than too much. Never feed more than the birds will eat up clean. In selecting food two things must be remembered—that variety tempts appetite and that a gradual transition from soft to hard food is required. Even seed-eating birds, such as sparrows and other finches, feed their young at first almost exclusively on soft-bodied insects. Young pheasants pick up many insects in the rearing field, but the supply must be supplemented. It is customary to depend on so-called ants' eggs (really the pupæ of ants), maggots, meal worms, or finely ground meat. Almost any soft-bodied insects would satisfy the need if they could be secured in sufficient quantity. Ants' eggs are much relished by young pheasants and are excellent food; but it is difficult to obtain enough of them, and unless they

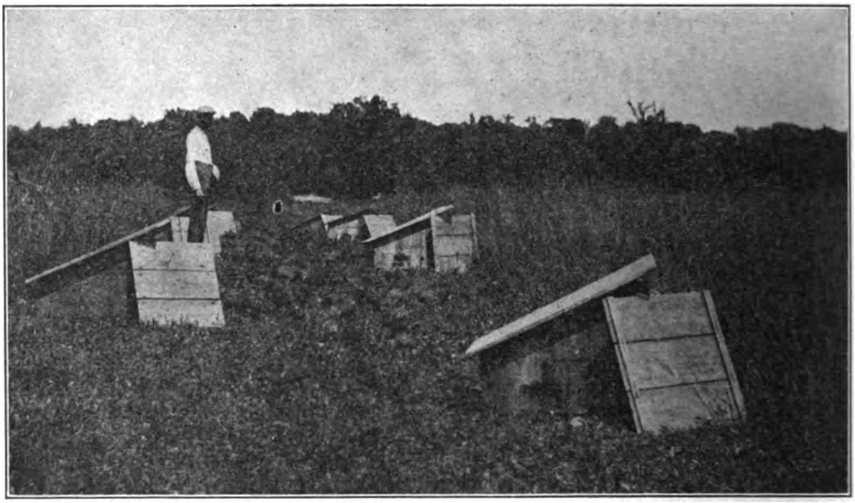

FIG. 16.—Coops used on a New Jersey preserve. (These coops are closer together than usual.)

can be obtained throughout the season it is better not to use them at all, as chicks will reject other food after having been fed on them. Meal worms are very satisfactory, but are difficult to raise in sufficient quantity. Maggots are equally good, and enough can be produced cheaply. The customary method is to suspend a piece of meat, or the carcass of a dead animal, over a barrel or tub of bran. The flesh becomes flyblown and the maggots drop into the bran. Before they are used the maggots must be thoroughly cleansed or they are apt to cause purging. This is usually done by putting burlap or very fine mesh wire in place of the bottom of the barrel or box of bran. They will work their way down through the bran in search of food and may be caught in a receptacle below, all ready for feeding to the pheasants. This method is very offensive, and may be replaced by permitting a carcass to become flyblown and then burying it a few inches in the ground; the maggots will work their way to the surface, where they can be secured by the young pheasants. The Massachusetts Game Commission found sheep plucks the cheapest and most available material for producing maggots. Thirty-six plucks a week produce enough food for 200 young pheasants—36 to 48 quarts of maggots. Three times a week plucks were allowed to become flyblown, when they were taken into a small shed built for the purpose and hung on meat hooks. In about twenty-four hours the maggots dropped into boxes below containing 1 quart of ground beef scraps to 6 quarts of bran. They then dropped through the quarter-inch mesh wire cloth, of which the bottoms of the boxes were composed, into especially designed drawers. In four or five days after the meat was blown the maggots were fit for pheasant food. If not used within a few hours the maggots change into the chrysa-

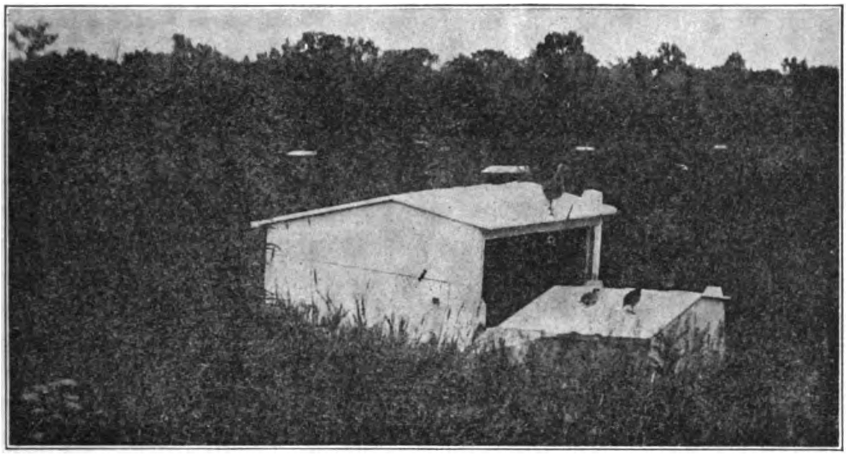

FIG. 17.—Coop used on an Illinois pheasantry.

lid state, unfit for the chicks; but development may be arrested for several weeks by keeping them in a temperature of 40 to 45 degrees. Care should be taken that unconsumed maggots be not permitted to transform in any considerable number into flies, as flies transmit disease.

The commission found the stench from raising maggots almost unbearable, and overcame the difficulty by exposing slightly tainted meat to the flies, cutting out the egg clusters as they appeared (with a small piece of the meat), placing them in moist bran, and feeding the maggots twice a day on as much thinly sliced fresh meat as they would eat up clean. It was found necessary, not only to devise means to obtain a supply of maggots early in the season, but also to replenish the stock of flies in the neighborhood. Maggots can be raised unobjectionably in piles of rotting seaweed, and near the seacoast this method may be employed to advantage.

Owing to the numerous difficulties and annoyances attending the raising of maggots, ants' eggs, and meal worms, it is now the general custom to feed raw ground meat, which makes a fairly satisfactory substitute. Practically every specially prepared pheasant food on the market contains this ingredient.

No special food formula will be given here, as no fixed rule will meet all conditions. For the first three or four days the chicks are usually fed on a stiff custard of eggs and milk (10 eggs to each quart of milk, baked dry), with sometimes a little oatmeal added, but some successful pheasant raisers use hard-boiled egg grated fine, mixed with other food, such as browned bread crumbs, cracked wheat, finely cut onion tops or lettuce, crushed hemp seed, or canary seed.

After three or four days of the egg diet, whether custard or hard-boiled egg, more substantial food should be added and the egg gradually decreased. It is usual, while reducing the egg food, to feed a dry crumbly mash containing a number of different ingredients, such as corn meal, oatmeal, barley meal, boiled rice, a little ground meat, and some finely chopped lettuce, water cress, grass, dandelion leaves, onion tops, cabbage, chickweed, garlic, or similar green food. Canary, millet, or hemp seed may be added in small quantities for variety. A good general rule is "variety of dry food and liberality of green food." A satisfactory ration is composed of 1 quart of milk, 1 quart of bone flour, 2 quarts of corn meal, 2 quarts of wheat middlings, and 1 pint of beef scraps (ground fine).

After two or three weeks coarser ground food may be supplied safely and the grain gradually increased, both in size and quantity, until the fifth week, when whole wheat, barley, cracked corn, oats, and buckwheat may be added. Sunflower seeds, boiled potatoes, kafir corn, chopped artichokes, chopped onion, and baked bread crumbs are a few serviceable components of pheasant food that may be used to vary the diet as the chicks approach maturity. In wet or cold weather a little pepper in the food is beneficial at all stages, and at the age of five weeks, when the full strength of the young pheasant is demanded for growing feathers, a little tonic solution of sulphate of iron added to the water daily has been tried with good effect.

As before stated, however, the change of food and the proportions in which different ingredients are combined must be determined largely by the judgment and experience of the one in charge of the birds. The nature of the locality, the character of the season, the abundance or scarcity of insect food, the kind of rearing field—these and other matters must be taken into account. The treatment here prescribed will serve as a foundation for the care of all kinds of pheasants.

After the first twenty-four hours food should be given every two hours for the first week or two; thereafter the feeding should be gradually reduced to three times a day at two or three months—that is, feedings should be two hours apart for the first and second weeks, three hours apart for the third week, and four hours apart for the fourth week and thereafter to about the tenth week.

While small, pheasant chicks heed the call of the brooding hen, after they learn it; but as they grow they become more and more independent, and usually show a tendency to stray. When they no longer need the fostering care of the hen they should be placed in large pens. Their wings must now be clipped, unless the pen be wired above.

CARE IN WINTER.

Many species of pheasants are able to withstand cold. Even when the mercury is below zero, they generally prefer to roost in the open runs, and they seem to be little discommoded by snow. Nevertheless, it is well to afford them shelter from severe storms and from excessive dampness; and some species normally inhabiting warm regions require housing in cold weather. Scrupulous cleanliness must be maintained throughout the winter, as at other seasons, and dust baths must be provided at all times. It is necessary to remember also that grit or fine gravel is essential to the proper digestion of food by pheasants. In winter it is not usually necessary to separate the cocks from each other or from the hens.

MARKETING PHEASANTS.

The successful raiser of pheasants will have surplus stock to dispose of. Cock pheasants are produced out of proportion to the number required for breeding; hens more than 2 years old are generally discarded for breeding purposes; and the natural increase will tend to outrun the limitations of the successful propagating plant. Under these circumstances many will wish to market their surplus. There is at present no lack of demand for pheasants for various purposes.

Live ringnecks and English ringnecks can always be disposed of to owners of private preserves and state game officials, for stocking covers, and to a smaller extent English, versicolor, Mongolian, and Prince of Wales pheasants will find a similar market. Zoological and city parks and owners of private aviaries are ready purchasers of the rarer and the more beautiful species. At present the demand for pheasants is increasing. Large numbers of dead pheasants are annually imported from Europe to be sold for several times the price they bring in European markets. In America, several states have recently passed laws permitting the marketing of domesticated game with suitable safeguards to prevent the unlawful marketing of native wild game under this privilege—a fact which indicates that American markets will open more and more to pheasant raisers.

SHIPMENT OF LIVE BIRDS.

The shipment of dead birds to market is simple, but a few words of advice as to methods of shipping live pheasants will be serviceable. Pheasants intended for shipment should be caught in deep nets a foot and a half wide that are provided with long handles. When put in crates, they must be held with the wings pressed against the sides and not carried by the legs, which are easily dislocated. The crate used should be deep enough to allow the birds to stand upright and commodious enough to avoid damage to their long tails (some breeders, when shipping, economize space by cutting off the tail feathers, which will grow out again at the next molt). The top of the crate should be of wood for long distances or wire for short distances. When of wood it should be amply padded, as pheasants, when frightened, jump up with such violence as to break their necks or scalp themselves if the top be solid. Burlap, stuffed 2 inches deep with straw, is a good padding. Ventilation should be provided by means of small holes near the top, and one side should be closed only by 1 or 2 inch mesh wire, with a loose burlap or cheese-cloth curtain, to allow sufficient air and at the same time prevent the pheasants from seeing out and thus suffering frequent alarms. The crates should have handles. The bottom should be covered with short straw. An ample supply of grain and water for the journey should be provided, or the express messenger should be instructed to supply these en route. For a journey of not more than forty-eight hours, green, succulent food, such as apple or cabbage, fastened inside the crate will supply all the food and water necessary. Lastly, the crate should be labeled "Live birds—rush."

Eggs may be shipped in various ways. They may be packed in cotton, hay, excelsior, or almost anything that will prevent breakage. It is necessary only to caution the shipper not to use sawdust, as the resin is likely to spoil the eggs.

DISEASES OF PHEASANTS.

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Health and disease are closely correlated with freedom and confinement. In the case of poultry, accustomed by long domestication to limited quarters, the larger the range the stronger the bird. The converse of this proposition is only too familiar to those who have attempted to rear pheasants. In fact, having pheasants in mind, one is tempted to formulate the law that the hardier the bird in the natural state, the greater the vigilance required to maintain it in health in captivity.

The first principle, then, in pheasant hygiene, is the recognition of the fact that health is more or less menaced by confinement, which necessitates curtailment of exercise, artificial alimentation, and unnatural shelter. It has been the object of the foregoing chapters to obviate these dangers as far as possible by suggestions as to the location and laying out of the pheasantry, the foods and methods of feeding, and the special care of the birds during the breeding season. However, as, in spite of the most careful attention, there will still be the possibility of diseases, this chapter will indicate methods of avoiding preventable diseases, and will suggest curative measures, wherever possible, for the others.

DISINFECTION.

The subject of disinfection (and along with it that of disinfectants) is one of extreme importance in even the most cursory sketch of diseases and their treatment. Its importance increases in one's mind in proportion to his apprehension of the extent and seriousness of infectious diseases. The fact that many diseases are caused by parasites, and are therefore transmissible directly or indirectly from one bird to another, or even from other animals to birds, makes apparent the necessity for thorough destruction of disease-producing parasites.

Disinfection of the grounds or runs is of supreme importance, and should be practiced not merely for the suppression of an outbreak of disease, but regularly as a routine method of preventing such outbreaks. Fire is the best disinfectant, and where disease agents are known to assume very resistant conditions, as, for instance, the eggs of worms or the spore cysts of the lowest animal forms like the protozoa, fire is the only absolutely reliable disinfectant. Where there is no danger to buildings, the ground may be sprinkled with kerosene and flamed. Even here we must recognize one possibility of failure. Earthworms may act sometimes as carriers of disease agents, and convey into the ground, on their bodies or in their alimentary tracts, such agencies of disease as the eggs of the gape worm, or even the gape worm itself. After the ground has been flamed, and the surface thus perfectly disinfected, rain may bring the worms to the surface and with them the parasites they are carrying. Hence the necessity from time to time of another very good disinfecting procedure, namely, top-dressing with lime and plowing under. Where fire can not be used, this method is invaluable. Since some diseases appear to arise from contamination of the soil from prolonged occupancy, top-dressing with lime, plowing, and sowing some quick-growing green manure, such as cowpeas and oats, should be regarded as necessary routine. A third method of disinfection of the soil consists in sprinkling or deluging the ground with a solution of sulphuric acid (1 part acid to 9 parts water) or a 5 percent solution of carbolic acid (1 part acid to 19 of water).

Disinfection of buildings or parts of buildings involves the same principles. It may sometimes be best to burn old houses, or tear out old fixtures and burn them. Next in value is a thorough washing and scrubbing with hot water and soap and the application by spray or brush of a 5 per cent carbolic-acid mixture containing enough lime to show where it has been applied. A coal-tar disinfectant, if known to be good, may be used in place of the carbolic acid.

DISEASES AFFECTING YOUNG PHEASANTS.

Pasting.—Pasting occurs usually during the first week of life. The chick loses its vivacity, sits with eyes closed and its downy coat fluffed until it appears like a ball. Examination reveals the vent plugged or covered by a whitish, chalky, or pasty substance. This stoppage of the vent frequently leads to death in a day or two as the result of the absorption of putrefactive poisons due to retention of the feces. Treatment consists in the immediate gentle removal of this chalky plug and the application of a few drops of sweet oil or a bit of petrolatum.

Diarrhea.—*Whitish* diarrhea may be caused in very young chicks by cold, by overheating, by overfeeding, or by too little or too much water. The observant fancier will come to recognize these conditions almost instinctively and will relieve them by at once altering the régime. This should be all that is necessary. If more is required, it is evident that either the case has been permitted to run so long that the chick is too weak to recuperate or infection is operating.

White diarrhea of chicks, so dreaded by the poultryman, is an affection of pheasant chicks as well. The diarrhea is merely a symptom of a severe infection of the intestines, especially of the blind pouches or ceca, by a low form of animal life known as *Coccidium tenellum*, and we therefore speak of the disease as an intestinal coccidiosis. The white coloration of the fecal discharge, as in the two previous diseases, is due to excretions from the kidneys. In certain virulent forms of the disease the minute blood vessels on the inner portion of the intestinal wall burst, and the bleeding gives rise to a dark brown or even blackish coloration, which obscures the white effect of the uric acid.

Treatment should begin with the administration of Epsom salts, mixing them in a mash and estimating from 8 to 15 chicks to one teaspoonful of the salts, according to age, size, and previous thriftiness. The drinking water should contain sulphate of iron (copperas) in the proportion of 10 grains of the copperas to 1 gallon of water, or enough permanganate of potash may be added to the drinking water to give the water a claret-red color. The coops, feeding utensils, drinking vessels, and runs should be disinfected, as previously directed (see p. 35). As a preventive measure, incubators and brooders should be cleansed and disinfected, and, prior to incubation, whether natural or artificial, the eggs should be dipped in 95 per cent alcohol or in a 4 per cent solution of some good coal-tar disinfectant.

Gapes or gape disease.—The disease known as gapes is particularly fatal to young pheasants. The two names given above are derived from its chief symptom. It is caused by a worm called *Syngamus trachealis*, the generic name, *Syngamus*, recognizing the permanent sexual union that exists between the male and female. For this reason the worm is also called the branched worm, forked worm, and Y worm. From its color it is known as the red worm. Attached to the wall of the chick's windpipe by means of the sucker on the head end of both male and female portions, it is only with great difficulty loosened by sneezing and coughed up. Death usually results from suffocation due to obstruction of the windpipe by the large, well-fed worm distended with blood drawn from its host, or to the presence of a few worms and excessive mucus combined, or again, to the presence of a large number of worms.

In addition to the symptom of gaping, there is a peculiar stretching out of the neck, with an actual gasping for breath. Many claim to be able to diagnose the disease by a characteristic sudden, whistling cough somewhat like a sneeze. However, as these symptoms might be easily counterfeited by bronchitis, pneumonia, so-called brooder pneumonia, which is really a mold infection of the lung, and roupy disease of the larynx and windpipe, the only sure means of demonstrating the disease is to find the worm.

The usual method of treatment is to take a horsehair formed into a loop, a small feather from which have been removed all barbs save those at the tip, a timothy head treated in the same manner as the feather, or even (if great care is exercised) a very thin wire twisted into a loop, pass it gently down into the windpipe, and, after making a few turns, carefully withdraw it. Sometimes these instruments, before being used, are dipped in sweet oil, or sweet oil containing a few drops of turpentine. In this way the worms are either withdrawn or loosened from their attachment to the windpipe, so that the chick can cough them up. Garlic in the drinking water or mixed with the food has often proved efficacious.

Since the disease is spread by the young birds taking in with their food the worms and their eggs that have been coughed up by infected birds, one of the first steps in treatment is to remove all the birds from the infected ground and to separate the sick from the well. The infected ground should be immediately treated so as to destroy the gape worms and their eggs. As the earthworm has been shown to be, not an intermediate host, but a carrier of the gape worms or its ova, the surest way of raising the young chicks where the ground has probably been infected is to rear them on board floors.

Another method of treatment is fumigation. A smudge may be made from tobacco; tar or sulphur may be vaporized; or carbolic-acid fumes may be produced by pouring a small quantity into boiling water. Caution must be used in the application of this method, as there is great danger of suffocating the birds or of their being overcome by the drug effect of the substances volatilized.

Cramps.—Under the name of cramps, used by the keepers of pheasants, Dr. E. Klein, of England, has described a disease which causes great mortality among birds during the second and third weeks of life. It begins with lameness in one leg, followed the next day by lameness in the other. Death occurs, as a rule, on the third day. Post-mortem reveals softening and fracture of the thigh bone and of the bone of the leg, associated with the presence of considerable blood in the surrounding tissues. The only treatment is to destroy the bird, burn the carcass, and disinfect the grounds and houses.

DISEASES AFFECTING MAINLY ADULT PHEASANTS.

Roup.—Certain affections known as contagious catarrh, diphtheria, and roup, if, indeed, they be distinct diseases, generally group themselves in the fancier's mind under the one name, roup. The term diphtheria should not be used, because it belongs properly to that disease in the human family which is caused by a special bacillus which does not cause disease in birds. The other two names may represent two different stages of the same disease, a contagious inflammation of the mucous membranes of the eyes, nose, mouth, throat, gullet, or windpipe, which may express itself by a watery, sticky, bad-smelling secretion, or by the development of yellowish patches.

In the treatment of these affections the first thing is to recognize the contagiousness and to isolate the sick birds. Disinfect houses and grounds. Make a mixture of peroxide of hydrogen and boiled water, equal parts; into this plunge the head of the affected bird. By means of a slender wire covered with a little absorbent cotton and dipped in this mixture clean out of the eye or scrape off the tongue and sides of the mouth all yellowish matter and apply a 4 per cent solution of borax or boracic acid or the peroxide solution named above. Give all birds, sick and well, a dose of Epsom salts. Keep iron sulphate or permanganate of potash in the drinking water.

Pneumonia.—Pneumonia as a popular term in bird diseases probably often includes inflammation of the windpipe, inflammation of the bronchial tubes (bronchitis), and inflammation of the lungs. Difficult breathing, wheezing, coughing, and shaking the head, associated with the usual symptoms of feverishness, weakness, and loss of appetite, call for treatment. A purgative, such as Epsom salts or a teaspoonful of castor oil, should be given first. Keep the bird in a dry place. From time to time allow it to inhale the fumes of burning sulphur or tar or the vapors arising from carbolic acid in boiling water. Do not allow the fumes to become too dense.

Enteritis.—Enteritis, as used in bird medicine, means inflammation of the intestines. While it may originate from cold, improper feeding, and the like, it is usually an infectious disease and calls for prompt cleansing of the digestive tract, which is best accomplished by Epsom salts or a teaspoonful of castor oil containing about 15 drops of turpentine. Add iron sulphate or permanganate of potash to the water; isolate the affected birds. Disinfect thoroughly the houses, utensils, and grounds, and sprinkle lime everywhere. The causes may be coccidia, such as we find in white diarrhea of chicks; flagellates, as in the canker of pigeons; or bacteria, as in Klein's infectious enteritis.

Cholera.—Cholera would really come under the third class just mentioned. The organism causing it is frequently so virulent that death comes within a few hours, even before the diarrheal symptoms have had time to manifest themselves. The treatment would be practically that outlined under enteritis, although treatment is usually of no avail. Kill the very sick and treat only the apparently healthy, thus anticipating and preventing the disease. Necessary in all the other diseases, it is of supreme importance in cholera to burn quickly all dead birds, after saturating them with coal oil. Burying deep and covering with lime may have to do, but it is not so good a method. In killing the sick birds do not use the ax, and thus spatter everything with the infective blood.

Scurfy legs.—The affection known as scurfy legs, scaly legs, scabies, or mange of the legs and feet is caused by a parasitic mite, *Sarcoptes mutans*, which burrows under the scales and by its presence sets up an irritation which causes a rapid increase in production of cells, together with a secretion resulting in a gradual thickening and elevation of the scales. Being a parasitic disease, scaly legs is transmissible from one bird to another and from infested houses, perches, nests, etc. Treatment must begin with isolation of the patient and the thorough application to the coops and fixtures of boiling soapy water, then kerosene, and finally a coat of 5 per cent carbolic acid, to which has been added enough lime to make a whitewash. The affected bird should have its legs soaked in warm soapsuds, this part of the treatment being completed by a good scrubbing with a small hand scrub. This alone has cured the disease. However, it is best to follow this with a good rubbing of sulphur ointment (1 part flowers of sulphur to 9 parts of lard, sweet oil, or petrolatum).

Scab.—Body mange or scab is caused by a sarcoptic mite, to which some authors have given the name *Sarcoptes lævis*. Loss of feathers at various points of the body calls for examination, which shows the skin apparently normal, but the feathers broken off at the surface. If the rest of the feather be pulled out, the roots will be seen to be covered with a dry, powdery mass made up of dead cells and parasites. Treatment calls for isolation of diseased stock, disinfection of coops and fixtures, and application to the skin of flowers of sulphur in the form of either a dusting powder or an ointment. The application of sweet oil containing a small quantity of kerosene or carbolic acid, carbolated petrolatum, or even lard with carbolic acid, will be found to give good results.

Air-sac mite.—Serious disease is frequently caused in a flock by the presence of the air-sac mite. This mite, *Cytodites nudus*, inhabits the air sacs of birds, chiefly those of chickens and pheasants. Often its presence in large numbers causes congestion and inflammation of the lining membrane of the air sacs. Sometimes the bronchi become plugged with them, sometimes a pneumonia is set up, sometimes the irritation opens the way for the entrance of bacteria which cause secondary disease and death. Treatment is very difficult and unsatisfactory. Sulphur mixed in the food has been recommended. The inhalations and garlic treatment suggested under gape disease might be beneficial.

White comb.—White comb or favus is a fungous or mold disease of the comb, head, and neck. It is caused by the *Achorion schönleinii*. In general appearance favus resembles mange. There is the development of white, powdery scales upon the comb, and the feathers of the head and neck become brittle and break off at the surface of the skin. The affected parts should be anointed with some oily substance like lard or petrolatum. After a few hours, or the next morning, scrub the parts with soap and water, rinse, dry, and apply ichthyol ointment (1 part ichthyol to 9 parts of petrolatum). In very stubborn cases tincture of iodine may be applied.

Intestinal worms.—Pheasants frequently harbor considerable numbers of intestinal parasites. It has generally been considered that no harm results to the bird from the presence of worms in the intestinal tract. Nevertheless, it must be recognized that the plugging of a part of the intestine by a ball of these worms or a long knotted rope composed of them must seriously derange the intestinal functions. Serious inflammation of the intestines is often caused by some of these worms. Where it is evident that a flock is thus infested, Epsom salts should be administered at least once a month. Birds that appear markedly affected may be given one teaspoonful of castor oil containing 15 drops of turpentine. Since the disease is spread by birds taking up with their food the eggs that were in the droppings of diseased birds, the ground thus contaminated should be thoroughly disinfected.

Tuberculosis.—Tuberculosis is not a subject for treatment but for eradication and prevention. It is fairly common among domesticated pheasants and is often spoken of as 'going light.' However, not all cases of 'going light' are cases of tuberculosis. When a bird dies of tuberculosis a post-mortem examination will reveal the liver, spleen, and intestines more or less filled with yellowish, cheesy lumps ranging in size from that of a pinhead to that of a walnut. Under microscopic examination these nodules or tubercles must always show the bacillus of tuberculosis or the disease should not be called tuberculosis. There are other diseases characterized by lumps in the liver, spleen, and intestines. For this reason the first pheasant that upon post-mortem exhibits a nodular condition of the organs should be wrapped in rags previously soaked in 5 per cent carbolic acid and shipped to the laboratory of the Bureau of Animal Industry, Washington, D. C., or to the State Experiment Station, for diagnosis by microscopic examination.

When the disease is discovered isolate all 'going light' birds; disinfect their droppings; if they persist in their pallor and emaciation, destroy them; disinfect all grounds and buildings; keep lime sprinkled among the droppings. If hens are affected, but are still laying, cleanse the eggs in 95 per cent alcohol, hatch in a previously disinfected incubator, rear in sterilized brooders, and keep the chicks absolutely apart from all other stock. In this way a new flock completely free from tuberculosis can be developed.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 391.

ECONOMICAL USE OF MEAT IN THE HOME.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 31, 1910.

Sir: The widespread interest in the most satisfactory and most economical ways of preparing meat for the table has led to the preparation, in accordance with your suggestion, of the accompanying summary of information on the cheaper cuts of meat and inexpensive meat dishes, which I have the honor to submit and recommend for publication as a Farmers' Bulletin.

For many years the relative nutritive value and ease and thoroughness of digestion of the different kinds and cuts of meat, the relative losses sustained when meat of different kinds is cooked in various ways, the proportion of meat used in American homes, and similar questions have been studied as a part of the nutrition investigations of the Office of Experiment Stations. The nutritive value of meat has been studied in connection with experiments with the respiration calorimeter devised by the Office, and additional work along such lines is being carried on. This apparatus is of great importance in the study of nutrition problems, as it permits the measurement of many factors with an accuracy not hitherto attainable. Furthermore, dietary studies under typical conditions in different parts of the country have given data of great practical importance, while general data have been compiled regarding the whole question of the use of meat as food. The information thus secured and the results of tests especially undertaken for the purpose have been used in preparing the present bulletin. Recipes collected from many sources have been tested, and the attempt has been made to present the material in such a way that it may illustrate the principles of meat cookery for the home table.

The production of meat has always been one of the principal subjects which have engaged the attention of the Department of Agriculture, agricultural colleges, and experiment stations, while the safeguarding of the meat supply by inspection is one of the very important functions of the Bureau of Animal Industry of the Department of Agriculture. The present bulletin has been prepared with a view to supplementing this work by pointing out the ways to use this important agricultural product when it reaches the home.

The bulletin was prepared by C. F. Langworthy, expert in charge of nutrition investigations, and Miss Caroline L. Hunt, who has had wide experience in the study of scientific and practical problems of nutrition. The recipes were collected from many sources and with few exceptions were studied experimentally by Miss Hunt.

Acknowledgment should be made to teachers of home economics in agricultural colleges and other educational institutions and to housekeepers and others who have supplied recipes and other data of great value in preparing the bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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ECONOMICAL USE OF MEAT IN THE HOME.

INTRODUCTION.

Owing to its wide range of climate and soil the United States produces the staple foods in great variety and abundance, as well as many of those which are usually termed "luxuries." For this and for other reasons the problem of selecting an ample and pleasing diet is a simpler one than in many countries where food materials are less plentifully produced.

The foods used to give variety to the diet vary with time, place, and circumstances, but the staple foods the country over are cereal grains and their products, meat, dairy products, eggs, and the more usual vegetables and fruits. According to the results of a large number of carefully conducted studies in American homes, it appears that meat and poultry supply 16 per cent of the total food material, 30 per cent of the protein, and 59 per cent of the fat in the average American dietary; dairy products, 18 per cent of the total food, 10 per cent of the total protein, 26 per cent of the total fat, and 4 per cent of the total carbohydrates; cereals and their products, 31 per cent of the total food material, 43 per cent of the total protein, 9 per cent of the total fat, and 62 per cent of the total carbohydrates; and vegetables and fruits together, 25 per cent of the total food, 9 per cent of the total protein, 2 per cent of the total fat, and 16 per cent of the total carbohydrates. These figures indicate clearly the relation which the principal agricultural products must of necessity bear to home problems. The utilization of these staple foods to the best advantage is of great importance to every housekeeper.

Many problems connected with the nutritive value of these staple agricultural products, their preparation for the table, digestibility, palatability, and the hygienic and economic aspects of the question have been studied in connection with the nutrition investigations of the Office of Experiment Stations. The laboratory work, which has been very extended and which has included experiments with the respiration calorimeter, has yielded results of great practical value as well as of scientific importance. The results of these experimental studies are brought together in this discussion of the economical use of meat in the home.

VALUE OF MEAT AS FOOD.

Considering the fact that meat forms such an important part of the diet and the further fact that the price of meat, as of other foods, has advanced in recent years, it is natural for housekeepers to seek more economical methods of preparing meat for the table, and to turn their thoughts toward the less expensive cuts and ask what economy is involved in their use, how they may be prepared, and whether the less expensive dishes are as nutritious and as thoroughly and easily digested as the costlier ones.

The value of meat as food depends chiefly on the presence of two classes of nutrients, (1) protein or nitrogenous compounds, and (2) fat. The mineral matter it contains, particularly the phosphorus compounds, is also of much importance, though it is small in quantity. Protein is essential for the construction and maintenance of the body and both protein and fat yield energy for muscular power and for keeping up the temperature of the body. Fat is especially important as a source of energy. It is possible to combine the fat and protein of animal foods so as to meet the requirements of the body with such materials only, and this is done in the Arctic regions, where vegetable food is lacking; but in general it is considered that diet is better and more wholesome when, in addition to animal foods, such as meat, which is rich in proteins and fats, it contains vegetable foods, which are richest in sugar, starch, and other carbohydrates. Both animal and vegetable foods supply the mineral substances which are essential to body growth and development. In meat mineral matter constitutes about 0.3 to 1.9 per cent on an average of the total fresh material.

The composition of the various cuts of meat and similar topics have been discussed in more detail in an earlier bulletin of this series.[a] The general differences between the various cuts are shown in the following table:

Average composition of edible portion of different cuts of meat.

Kind of meat.	Water.	Protein.	Fat.	Ash.	Fuel value per pound.
Beef:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Brisket	54.6	15.8	28.5	0.9	1,495
Chuck rib	66.8	19.0	13.4	1.0	920
Flank	59.3	19.6	21.1	.9	1,255
Porterhouse	60.0	21.9	20.4	1.0	1,270
Neck	66.3	20.7	12.7	1.0	920
Ribs	57.0	17.8	24.6	.9	1,370
Round	67.8	20.9	10.6	1.1	835
Shank	70.3	21.4	8.1	.9	740
Side	62.2	18.8	18.8	.9	1,145
Veal: Side, with kidney, fat, and tallow	71.3	20.2	8.1	1.0	715
Mutton: Side, without tallow	53.6	16.2	29.8	.8	1,560
Lamb: Side, without tallow	58.2	17.6	23.1	1.1	1,300
Pork:					
Tenderloin	66.5	18.9	13.0	1.0	900
Chops	50.7	16.4	32.0	.9	1,655

It will be noted that the difference between the cuts is chiefly in the amount of the fat and consequently in the fuel value. So far as the proteins are concerned, i. e., the substances which build and repair the important tissues of the body, very little difference is found in the items included in the table, the maximum being 21.9 in porterhouse steak and the minimum 15.8 in brisket of beef, a range which is not especially significant when the total quantity of meat protein in the ordinary diet is taken into account. For all practical everyday purposes, therefore, it may be considered that the protein obtained from a given weight of meat differs very little either with the kind of meat or the cut. The fattest portions of pork, which are used for salt pork or cured pork and bacon, are exceptions, and in such cuts the proteins may be as low as 8 or 9 per cent.

This general uniformity in proportion of protein makes it easy for the housekeeper who does not wish to enter into the complexities of food values to make sure that her family is getting enough of this nutrient. From the investigations carried on in the Office of Experiment Stations the conclusion has been drawn that of the total amount of protein needed every day, which is usually estimated to be 100 grams or 3½ ounces.[b] one-half or 50 grams is taken in the form of animal food, which of course includes milk, eggs, poultry, fish, etc., as well as meat. The remainder is taken in the form of bread and other cereal foods and beans and other vegetables. The portion of cooked meat which may be referred to as an ordinary "helping," 3 to 5 ounces (equivalent to 3½ to 5½ ounces of raw meat), may be considered to contain some 19 to 29 grams of protein, or approximately half of the amount which is ordinarily secured from animal food. An egg or a glass of milk contains about 8 grams more, so the housekeeper who gives each adult member of her family a helping of meat each day and eggs, milk, or cheese, together with the puddings or other dishes which contain eggs and milk, can feel sure that she is supplying sufficient protein, for the remainder necessary will be supplied by bread, cereals, and other vegetable food.

The food value of any material of course depends upon the amount of its nutrients which the digestive organs can make available for the use of the body as well as upon its chemical composition; hence digestibility must be considered in comparing different kinds of food. The question whether the cheaper cuts prepared by the longer method are as thoroughly and as easily digested as the better cuts broiled or roasted has been satisfactorily answered by work which has been done as part of the nutrition investigations of the Office of Experiment Stations.[a] The results obtained show that, so far at least as present knowledge is concerned, there is practically no difference between the various cuts of meat or the meats from different animals with respect to either the thoroughness or the ease with which they are digested. Over 95 per cent of the protein and of the fat of all kinds and cuts of meat is digested by the body under normal conditions, which means that meat is a very thoroughly assimilated food and that there are no marked differences in the thoroughness with which different sorts are digested. The experimenters say: "It is commonly said that meats of different sorts vary decidedly in digestibility; for instance, that red meat is less digestible than white meat, or pork than beef, or that a cheaper cut is less digestible than a tender steak. As regards the thoroughness of digestion, the results of the extended series of tests reported show that such differences do not exist in any appreciable degree and that meat of all kinds and cuts is to be classed with the very digestible foods." Therefore, those who wish to use the cheaper cuts need not feel that in so doing their families are less well nourished than by the more expensive meats.

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[a] U. S. Dept. Agr., Farmers' Bul. 34.

[b] One ounce equals 28 grams.

PROPORTION OF DIFFERENT CUTS AND THEIR RELATION TO MEAT PRICES.

The price which the producer receives for the animal he has fattened for market must of necessity be a determining factor in fixing the price of meat which the consumer pays. The producer's price varies with a variety of conditions, including the cost of grain used in feeding animals, the rates of transportation, and other factors. The animal is usually marketed by the producer at so much a pound on the basis of live weight or of dressed weight. From the results of a large number of experimental tests at the agricultural experiment stations and data recorded by abattoirs and packing houses, the relation of dressed to live weight has been ascertained, the dressed weight in the case of beef animals being on an average 60 to 65 per cent of the live weight. The number and kind of cuts into which the dressed carcass is divided vary somewhat in different markets, though there is a greater tendency to uniformity in the United States than was once the case. In general, the cuts correspond to the anatomical structure of the animal and to the character of the muscular tissue.

The agricultural experiment stations in Iowa, Kansas, Minnesota, Illinois, and most of the other States have studied a variety of problems connected with the production of farm animals for market and have contributed much data of interest in connection with such problems. On the basis of investigations like those referred to, it has been found that on an average in the case of beef animals the ribs constitute 9 per cent of the total dressed weight, the loins 19 per cent, the chucks (with shoulder, neck, and brisket) 27 per cent, the plates 13 per cent, the shanks 3 per cent, the rounds (including rump) 23 per cent, the flanks 3 per cent, and the suet 3 per cent.

The muscular tissue which has been most concerned in the muscular work which the animal has performed is less tender than that which has been less used and differences in flavor are also influenced by similar causes. It naturally follows, therefore, that the different cuts of meat are not considered equally desirable; consequently, when cut up by the market man, the different cuts sell for a variety of prices.

In commercial transactions some percentage of advance in the selling over the buying price must be expected if the dealer is to be successful, and such factors as the cost of handling, storing, marketing, and possible deterioration during storage must be taken into account. The relation of such factors to particular cases is of fundamental importance in understanding commercial transactions.

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[a] U. S. Dept. Agr., Office of Expt. Stas. Buls. 141, 162, and 193.

The simplest method of fixing market prices would doubtless be to determine upon a reasonable percentage of increase which would be the same for all cuts. Such a custom has been followed in many localities. For instance, it was at one time the common practice in markets in Cuba and Mexico, particularly in small towns, to sell the whole carcass at a uniform price per pound, a custom still followed, but which does not long survive in a locality much influenced by outside conditions. In the United States, as every one knows, the price varies with the kind of meat and with the cut.

When the wholesale dealer buys meat from the producer he pays a certain uniform price per pound for the carcass on the basis of either live or dressed weight. In determining upon the advance over cost price, which is to be his selling price, it is customary to take into account the fact that the carcass is made up of a number of cuts and that some of them are considered more desirable than others and will therefore sell for a higher price. So it is a common custom to assume that the more desirable cuts have cost a higher price and that the less sought after cuts have cost a lower price than the uniform price which was actually paid per pound for the carcass. In other words, the wholesaler distributes his original total cost in a manner convenient from a commercial standpoint for making selling prices. Thus, as an illustration, if the carcass which was purchased at a uniform price of 10 cents per pound be assumed to supply 10 pounds of some choice cut and 10 pounds of some cheaper cut, the assumption might be made that the choice cut cost 15 cents per pound and the cheaper cut 5 cents per pound, without changing the total sum paid for both at the assumed uniform purchase price.

The table following, which is based upon a considerable amount of data collected in connection with Department of Agriculture work, summarizes information of this sort and shows the estimated cost to the wholesaler of the different cuts of beef when the carcass is purchased dressed at a uniform price ranging from 4¾ to 8 cents per pound. In distributing the total cost the weight of the different cuts is of course taken into account.

Estimated cost to the wholesaler of different cuts when the carcass is purchased at certain prices per pound, dressed weight.

Assumed sale price per pound of carcass.	Estimated cost of cut.							
	Ribs.	Loins.	Chucks.	Plates.	Shanks.	Rounds.	Flanks.	Suet.
Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
4¾	7	8	3½	2½	2	4¼	3	3
5	7¼	9	4	3	2	5	3	3
5¼	7¾	9½	4	3¼	2	5	3	3
5½	8	10	4	3¼	2	5	3	3
5¾	8½	10½	4¼	3¼	2	5¼	3	3
6	9	11	4½	3½	2	5½	3	3
6¼	9½	12	4¾	3½	2	5¾	3	3
6½	10	12½	4¾	3½	2	5¾	3	3
7	11	14	5	3½	2	5¾	3	3
7½	12½	15	5¼	3¾	2½	6¼	3	3
8	14	16	5½	4	3	6½	4	4

It is upon such data as the above table presents that the retail prices of meat are based theoretically, though of course many other factors, which vary with circumstances, must also be taken into account.

APPARENT AND ACTUAL COST OF MEAT IN DIFFERENT CUTS.

The relative retail prices of the various cuts usually bear a direct relation to the favor with which they are regarded by the majority of persons, the juicy tender cuts of good flavor selling for the higher prices. When porterhouse steak sells for 25 cents a pound, it may be assumed that in town or village markets round steak would ordinarily sell for about 15 cents, and chuck ribs, one of the best cuts of the forequarter, for 10 cents. This makes it appear that the chuck ribs are less than half as expensive as porterhouse steak and two-thirds as expensive as the round. But apparent economy is not always real economy, and in this case the bones in the three cuts should be taken into account. Of the chuck ribs, more than one-half is bone or other materials usually classed under the head of "waste" or "refuse." Of the round, one-twelfth is waste, and of the porterhouse one-eighth. In buying the chuck, then, the housewife gets, at the prices assumed, less than one-half pound of food for 10 cents, making the net price of the edible portion 22 cents a pound; in buying round, she gets eleven-twelfths of a pound for 15 cents, making the net value about 16½ cents; in buying porterhouse, she gets seven-eighths of a pound for 25 cents, making the net value about 28½ cents a pound. The relative prices, therefore, of the edible portions are 22, 16½, and 28½ cents; or to put it in a different way, a dollar at the prices assumed will buy 4½ pounds of solid meat from the cut, known as chuck, 6 pounds of such meat from the round, and only 3½ pounds of such meat from the porterhouse. To this should be added the fact that because of the way in which porterhouse is usually cooked no nutriment is obtained from the bone, while by the long slow process by which the cheaper cuts, except when they are broiled or fried, are prepared the gelatin, fat, and flavoring material of the bone are extracted. The bones of meats that are cooked in water, therefore, are in a sense not all refuse, for they contain some food which may be secured by proper cookery.

It is true, of course, that the bones of the steaks may be used for soup making, and that the nourishment may thus be utilized, but this must be done by a separate process from that of cooking the steak itself.

The facts discussed above are shown for a larger number of kinds of meat in the following table, which gives the proportion of bone and edible material in a number of cuts, together with the net price as compared with an assumed original price. As the cost of meat varies in different regions, in different markets, and at different times, it is impossible to give values which will represent a fair average market price. Those included in the table are simply selected to illustrate the point under consideration.

Net cost of edible portion of different cuts as compared with assumed market price[a] per pound.

Kind of meat.	Proportion of bone or waste in cut.	Proportion of edible material in cut.	Assumed market price per pound.	Net price per pound of edible portion.
	Per cent.	*Per cent.*	*Cents.*	*Cents.*
Beef:				
Brisket	23.3	76.7	7.0	9.0
Rump	19.0	81.0	10.0	12.5
Flank	5.5	99.5	7.0	7.5
Chuck rib	53.8	46.2	10.0	22.0
Porterhouse	12.7	87.3	20.0	23.0
Neck	31.2	68.8	7.0	10.0
Ribs	20.1	79.9	15.0	20.0
Round	8.5	91.5	15.0	16.0
Shin	38.3	61.7	3.0	5.0
Heart	5.9	94.1	5.0	5.3
Tongue	26.5	73.5	22.0	29.8
Veal:				
Cutlets	3.4	96.6	20.0	21.0
Breast	24.5	75.5	12.5	17.0
Mutton:				
Leg	17.7	82.3	15.0	18.0
Chops	14.8	85.2	15.0	17.5
Forequarter cut for stewing	21.2	78.8	12.5	20.0
Pork:				
Loin	19.3	80.7	15.0	20.0
Salt pork	8.1	91.9	12.5	13.0
Bacon	8.7	91.3	20.0	22.0
Ham	12.2	87.8	20.0	23.0

[a] Prices vary greatly in different parts of the country. These prices are assumed for the purpose of making it possible to compare nominal with net prices.

TEXTURE AND FLAVOR OF MEAT.

Although meats vary greatly in the amount of fat which they contain and to a much less degree in their protein content, the chief difference to be noted between the cheaper and more expensive cuts is not so much in their nutritive value as in their texture and flavor. All muscle consists of tiny fibers which under the microscope are seen to have the form of tubes. These fibers are tender in young animals and in those parts of older animals in which there has been little muscular strain. Under the backbone in the hind quarter is the place from which the tenderest meat comes. This is usually called the tenderloin. Sometimes in beef and also in pork it is taken out whole and sometimes it is left to be cut up with the rest of the loin. In old animals, and in those parts of the body where there has been much muscular action, the neck and the legs for example, the muscle fibers are tough and hard. But there is another point which is of even greater importance than this. The fibers of all muscle are bound together in bundles and in groups of bundles by a thin membrane which is known as connective tissue. This membrane if heated in water or steam is converted into gelatin. The process goes quickly if the meat is young and tender; more slowly if it is tough. Connective tissue is also soluble in acetic acid, that acid to which the sourness of vinegar is due. For this reason it is possible to make meat more tender by soaking it in vinegar or in vinegar and water, the proportions of the two depending on the strength of the vinegar. Sour beef or "sauer fleisch," as it is known to Germans, is a palatable dish of this sort for which the recipe is given elsewhere. (See p. 22.) Since vinegar is a preservative this suggests a method by which a surplus of beef may be kept for several days and then converted into a palatable dish.

In a study of factors which influence tenderness, Lehmann[a] and his associates measured experimentally the relative tenderness of raw meat of different kinds and cuts from old and young animals, the effect of hanging and freezing upon tenderness, and also the effects of cooking. According to his summary, the toughness or tenderness of the individual meat fibers is a matter of the location of the cut, and his measurements showed that the raw fibers from an exterior cut (flank) were almost two and a half times as tough as those from an interior cut (tenderloin).

In the case of veal, the two sorts of cuts showed the same general differences as beef, but in a greater degree. The muscle fibers of mutton and pork, according to the experimental data which Lehmann cites, were in general more tender than beef.

Flavor in meat depends mainly on certain nitrogenous substances which are called extractives because they can be dissolved out or "extracted" by soaking the meat in cold water. The quality of the extractives and the resulting flavor of the meat vary with the condition of the animal and in different parts of its body. They are usually considered better developed in older than in very young animals. Many persons suppose extractives or the flavor they cause are best in the most expensive cuts of meat; in reality, cuts on the side of beef are often of better flavor than tender cuts, but owing to the difficulty of mastication this fact is frequently not detected. The extractives have little or no nutritive value in themselves, but they are of great importance in causing the secretion of digestive juices at the proper time, in the right amount, and of the right chemical character. The digestive tract may be likened to a piece of machinery which is beautifully built and adjusted and is ready to run and turn out its product as soon as a lever is moved which sets it in motion. The flavoring bodies of food, and especially those contained in meat, can be likened to the lever which sets the machinery in motion. Excitants to normal digestion are supplied by other foods as well, but meats, so physiologists believe, are especially important for the purpose. It is this quality which justifies the taking of soup at the beginning of a meal and the giving of broths, meat extracts, and similar preparations to invalids and weak persons. These foods have little nutritive material in themselves, but they are great aids to the digestion of other foods.

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[a] Arch. Hyg., 63 (1907), p. 134.

The amount of the extractives which will be brought out into the water when meat is boiled depends upon the size of the pieces into which the meat is cut and on the length of time they are soaked in cold water before being heated. A good way to hinder the escape of the flavoring matter is to sear the surface of the meat quickly by heating it in fat, or the same end may be attained by plunging it into boiling water. Such facts are known to all cooks and have recently been studied systematically at the Illinois Experiment Station in relation to the amounts removed and the losses which may be involved in different methods of cookery. Such solubility is taken advantage of in making beef tea at home and in the manufacture of meat extract, the extracted material being finally concentrated by evaporating the water.

GENERAL METHODS OF PREPARING MEAT FOR THE TABLE.

The advantages of variety in the methods of preparing and serving are to be considered even more seriously in the cooking of the cheaper cuts than in the cooking of the more expensive ones, and yet even in this connection it is a mistake to lose sight of the fact that, though there is a great variety of dishes, the processes involved are few in number.

An experienced teacher of cooking, a woman who has made very valuable contributions to the art of cookery by showing that most of the numerous processes outlined and elaborately described in the cook books can be classified under a very few heads, says that she tries "to reduce the cooking of meat to its lowest terms and teach only three ways of cooking. The first is the application of intense heat to keep in the juices. This is suitable only for portions of clear meat where the fibers are tender. By the second method the meats are put in cold water and cooked at a low temperature. This is suitable for bone, gristle, and the toughest portions of the meat, which for this purpose should be divided into small bits. The third is a combination of these two processes and consists of searing and then stewing the meat. This is suitable for halfway cuts, i. e., those that are neither tender nor very tough." The many varieties of meat dishes are usually only a matter of flavor and garnish.

In other words, of the three processes the first is the short method; it aims to keep all the juices within the meat. The second is a very long method employed for the purpose of getting all or most of the juices out. The third is a combination of the two not so long as the second and yet requiring so much time that there is danger of the meat being rendered tasteless unless certain precautions are taken such as searing in hot fat or plunging into boiling water.

It is commonly said that the cooked meat fibers are harder or less tender than the raw, which seems a natural assumption since the meat protein, like egg albumen, is coagulated by heat, and furthermore, the water is forced out from the individual muscle fibers and they are shortened and thickened by the application of heat. Apparently, however, such general deductions must be modified on the basis of the experimental data obtained in Lehmann's[a] laboratory, for he found marked differences in this respect between the interior cuts of beef, of which tenderloin is a typical example, and exterior cuts such as flank. When beef flank was cooked by boiling for two hours, the toughness of the fibers greatly increased during the first half hour of the cooking period, and then diminished so that at the end of the cooking period the meat was found to be in about the same condition with respect to toughness or tenderness of the fibers as at the beginning. On the other hand, in the case of the tenderloin, there was a decrease in toughness of the fibers throughout the cooking period which was particularly marked in the first few minutes of cooking, and at the end of the cooking period the meat fibers were only half as tough as before cooking.

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[a] Arch. Hyg., 63 (1907), p. 134.

A good idea of the changes which take place while meat is being cooked can be obtained by examining a piece of flesh which has been "cooked to pieces," as the saying goes. In this the muscular fibers may be seen completely separated one from another, showing that the connective tissue has been destroyed. It is also evident that the fibers themselves are of different texture from those in the raw meat. In preparing meat for the table it is usual to stop short of the point of disintegration, but while the long process of cooking is going on the connective tissue is gradually softening and the fibers are gradually changing in texture. The former is the thing to be especially desired, but the latter is not. For this reason it is necessary to keep the temperature below the boiling point and as low as is consistent with thorough cooking, for cooks seem agreed, as the result of experience shows, that slow gentle cooking results in better texture than is the case when meat is boiled rapidly. This is the philosophy that lies back of the simmering process.

When meat is cooked by roasting, broiling, or any other similar process the meat juices brown with the fat, producing substances which to most of us are agreeable to the senses of smell and taste alike. When meats are cooked in hot water such highly flavored substances are not so evident to the sense of smell, but nevertheless bodies of agreeable flavor which are perceptible to the palate are developed in the meat during the cooking process.

The question of the amount and character of the ingredients which escape from the meat and other changes occurring in it during cooking is too complicated to be discussed in detail here. Much careful experimenting along these lines has been done in experiment station and other laboratories,[a] and the results show that the losses vary considerably with the method of cooking employed, being of course greatest where small pieces of meat are subjected to prolonged cooking.

Among the principal conclusions drawn from the experiments referred to are the following: The chief loss in weight when meat is cooked is due to the driving off of water. When beef is cooked by pan broiling—that is, searing in a hot, greased pan, a common cooking process—no great loss of nutrition results, particularly if the fat and other substances adhering to the pan are utilized in the preparation of gravy. When beef is cooked by boiling, there is a loss of 3 to 20 per cent of material present, though this is not an actual loss if the broth is utilized for soup or in some similar way. Even in the case of meat which is used for the preparation of beef tea or broth, the losses of nutritive material are apparently small though much of the flavoring matter has been removed. The amount of fat found in broth varies directly with the amount originally present in the meat; the fatter the meat the greater the quantity of fat in the broth. The loss of water in cooking varies inversely with the fatness of the meat; that is, the fatter the meat the smaller the shrinkage due to loss of water. In cooked meat the loss of various constituents is inversely proportional to the size of the cut. In other words, the smaller the piece of meat the greater the percentage of loss. Loss also appears to be dependent somewhat upon the length of time the cooking is continued. When pieces of meat weighing 1½ to 5 pounds are cooked in water somewhat under the boiling point there appears to be little difference in the amount of material found in broth whether the meat is placed in cold water or hot water at the beginning of the cooking period. When meat is roasted in the oven the amount of material removed is somewhat affected by the character of the roasting pan and similar factors, thus the total loss in weight is naturally greater in an open than in a closed pan as the open pan offers more opportunity for the evaporation of water. Judging from the average results of a considerable number of tests it appears that a roast weighing 6 pounds raw should weigh 5 pounds after cooking, or in other words the loss is about one-sixth of the original weight. This means that if the raw meat costs 20 cents per pound the cooked would represent an increase of 4 cents a pound on the original cost; but this increase would of course be lessened if all the drippings and gravy are utilized. With the quantities used in the ordinary home the relative losses sustained in different methods of cooking meat are not great enough to be of particular importance with reference to economical management. However, in public institutions where a small saving per day for each inmate represents a large item in the course of a year, it may be desirable to select methods involving the least loss, which would mean that the advantage would lie with stewing and boiling rather than with broiling and roasting, so far as the relative losses of material are concerned. The relative economy of different methods of cookery depends very greatly upon the kind of fuel, the form of stove and oven, and other similar factors. These vary so much under different home conditions that it is difficult to draw general deductions though the subject has often been investigated. However, it may be said that is often possible to effect a saving if the housewife can so plan the cooking of meat and other foods as to take full advantage of the heat supplied by the fuel used.

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[a] U. S. Dept. Agr., Farmers' Buls. 34, 162, p. 9, and 193, p. 29; also Office of Expt. Stas. Bul. 141.

REDUCING THE EXPENSE FOR MEAT IN THE DIET.

The expense for meat in the home may be reduced in several ways, and each housekeeper can best judge which to use in her own case. From a careful consideration of the subject it appears that the various suggestions which have been made on the subject may be grouped under the following general heads: Economy in selection and purchase so as to take advantage of varying market conditions; purchasing meat in wholesale quantities for home use; serving smaller portions of meat than usual or using meat less frequently; careful attention to the use of meat, bone, fat, and small portions commonly trimmed off and thrown away and the utilization of left-over portions of cooked meat; and the use of the less expensive kinds.

The choice of cuts should correspond to the needs of the family and the preferences of its members. Careful consideration of market conditions is also useful not only to make sure that the meat is handled and marketed in a sanitary way but also to take advantage of any favorable change in price which may be due, for instance, to a large local supply of some particular kind or cut of meat. In towns where there is opportunity for choice, it may sometimes be found more satisfactory not to give all the family trade to one butcher; by going to various markets before buying the housekeeper is in a better position to hear of variations in prices and so be in a position to get the best values. Ordering by telephone or from the butcher's boy at the door may be less economical than going to market in person as the range of choice and prices is of course more obvious when the purchaser sees the goods and has a chance to observe market conditions. Each housekeeper must decide for herself whether or not the greater convenience compensates for the smaller range of choice which such ordering from description entails. No matter what the cut, whether expensive or cheap, it can not be utilized to the best advantage unless it is well cooked. Poorly prepared meat dishes are almost inevitably wasted at the table. As an illustration of the losses arising through unwise selection and poor cooking may be mentioned facts observed in dietary studies carried on by the Office of Experiment Stations. In many families where the income was fairly good the table and other conditions were far from satisfactory. In such cases the marketing was quite commonly done by a child or someone without knowledge or experience. In a particular instance the selection was expensive steak, which later was so badly cooked that it was hardly possible to eat it. A cheaper cut well cooked would have been much more satisfactory as well as more economical.

There is sometimes an advantage in using canned meat and meat products, and, if they are of good quality, such products are wholesome and palatable.

That economy is furthered by careful serving at table is obvious. If more meat is given at each serving than the person wishes or habitually eats the table waste is unduly increased. Economy in all such points is important and not beneath the dignity of the family.

In rural regions both in the United States and in Europe farmers sometimes cooperate in the maintenance of slaughterhouses and storehouses, thus making it easier to obtain fresh meat in hot weather. In a "meat club"[a] in this country, which was said to be successful, the members took turns in providing animals (lambs or heifers) for the slaughtering which was done in a special shed on three Saturdays of each month. The meat was distributed among the members according to a system previously agreed on, the different cuts going to the different members in rotation. A fixed price per pound was agreed on at the beginning of the season and at the end of the season accounts were balanced according to the weight of the animals provided by and of the cuts supplied to each member. Such a plan seems capable of extension to meet a variety of conditions, particularly in rural regions.

Various other phases of the question of lessening the expense for meat in the home are discussed in the following sections.

LESSENING THE AMOUNT OF MEAT USED.

In many American families meat is eaten two or three times a day; in such cases the simplest way of reducing the meat bill would very likely be to cut down the amount used, either by serving it less often or by using less at a time. Deficiency of protein need not be feared when one good meat dish a day is served, especially if such nitrogenous materials as eggs, milk, cheese, and beans are used instead. In localities where fish can be obtained fresh and cheap, it might well be more frequently substituted for meat for the sake of variety as well as economy. Ingenious cooks have many ways of "extending the flavor" of meat, that is, of combining a small quantity with other materials to make a large dish, as in meat pies, stews, and similar dishes. Such dishes and their preparation are spoken of elsewhere. (See p. 15.)

BUYING MEAT IN QUANTITY FOR HOME USE.

By buying in large quantities under certain conditions it may be possible to procure meat at better prices than those which ordinarily prevail in the retail market. The whole side or quarter of an animal can frequently be obtained at noticeably less cost per pound than when it is bought cut by cut, and can be used to advantage when the housekeeper understands the art and has proper storage facilities and a good-sized family. When a hind quarter of mutton, for example, comes from the market the flank (on which the meat is thin and, as good housekeepers believe, likely to spoil more easily than some other cuts) should be cooked immediately, or if preferred it may be covered with a thin layer of fat (rendered suet) which can be easily removed when the time for cooking comes. The flank, together with the rib bone, ordinarily makes a gallon of good Scotch broth. The remainder of the hind quarter may be used for roast or chops. The whole pig carcass has always been used by families living on the farms where the animals are slaughtered, and in village homes; town housekeepers not infrequently buy pigs whole and "put down" the meat. An animal 6 months old and weighing about 100 pounds would be suitable for this purpose. The hams and thin pieces of belly meat may be pickled and smoked. The thick pieces of belly meat, packed in a two-gallon jar and covered with salt or brine, will make a supply of fat pork to cook with beans and other vegetables. The tenderloin makes good roasts, the head and feet may go into head cheese or scrapple, and the trimmings and other scraps of lean meat serve for a few pounds of homemade sausage. In some large families it is found profitable to "corn" a fore quarter of beef for spring and summer use. Formerly it was a common farm practice to dry beef, but now it seems to be more usual to purchase beef which has been dried in large establishments. The general use of refrigerators and ice chests in homes at the present time has had a great influence on the length of time meat may be kept and so upon the amount a housewife may buy at a time with advantage.

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[a] Breeder's Gaz., 53 (1908), p. 232.

Pickling, smoking, and other methods of curing meat for home use has been discussed in an earlier bulletin[a] in this series.

The preservation of meat and meat products by canning is a matter of great importance, but it is almost wholly a commercial enterprise, as the difficulties in the way of successfully canning meat in the home are many.

UTILIZING THE FAT, BONE, AND TRIMMINGS IN MEATS, AND THE LEFT-OVER COLD MEATS.

In the percentage of fat present in different kinds and cuts of meat, a greater difference exists than in the percentage of proteids. The lowest percentage of fat shown in the table on page 6 was 8.1 per cent in the shank of beef; the highest was 32 per cent in the pork chops. The highest priced cuts, loin and ribs of beef, contain 20 to 25 per cent. If the fat of the meat is not eaten at the table, and is not utilized otherwise, a pecuniary loss results. If butter is the fat used in making crusts for meat pies, and in preparing the cheaper cuts, there is little economy involved; the fats from other meat should therefore be saved, as they may be used in place of butter in such cases, as well as in preparing many other foods. The fat from sausage or from the soup kettle, or from a pot roast, which is savory because it has been cooked with vegetables, is particularly acceptable. Sometimes savory vegetables, onion, or sweet herbs are added to fat when it is tried out to give it flavor.

Some illustrations of methods of preparing such cooking fats follow:

Trying out Fat.

A double boiler is the best utensil to use in trying out small portions of fat. There is no danger of burning the fat and the odor is much less noticeable than if it is heated in a dish set directly over the fire.

Clarifying Fat.

Excepting where the purpose of clarifying fat is to remove flavors, a good method to follow is to pour boiling water over the fat, to boil thoroughly, and then to set it away to cool. The cold fat may be removed in a solid cake and any impurities clinging to it may be scraped off, as they will be found at the bottom of the layer. By repeating this process two or three times a cake of clean, white fat may be obtained.

A slight burned taste or similar objectionable flavors often can be removed from fat by means of potatoes. After melting the fat, put into it thick slices of raw potato; heat gradually. When the fat ceases to bubble and the potatoes are brown, strain through a cloth placed in a wire strainer.

Savory Drippings.

When rendering the drippings of fat meat, add a small onion (do not cut it), a few leaves of summer savory and thyme, a teaspoonful of salt, and a little pepper. This is enough for a pint of fat. Keep the drippings covered and in a cool place.

Uses for Bones.

Almost any meat bones can be used in soup making, and if the meat is not all removed from them the soup is better. But some bones, especially the rib bones, if they have a little meat left on them, can be grilled or roasted into very palatable dishes. The "sparerib" of southern cooks is made of the rib bones from a roast of pork, and makes a favorite dish when well browned. The braised ribs of beef often served in high-class restaurants are made from the bones cut from rib roasts. In this connection it may be noted that many of the dishes popular in good hotels are made of portions of meat such as are frequently thrown away in private houses, but which with proper cooking and seasoning make attractive dishes and give most acceptable variety to the menu. An old recipe for "broiled bones" directs that the bones (beef ribs or sirloin bones on which the meat is not left too thick in any part) be sprinkled with salt and pepper (Cayenne), and broiled over a clear fire until browned. Another example of the use of bones is boiled marrow bone. The bones are cut in convenient lengths, the ends covered with a little piece of dough over which a floured cloth is tied, and cooked in boiling water for two hours. After removing the cloth and dough, the bones are placed upright on toast and served. Prepared as above, the bones may also be baked in a deep dish. Marrow is sometimes removed from bones after cooking, seasoned, and served on toast.

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[a] U. S. Dept. Agr., Farmers' Bul. 183.

Trimmings from meat may be utilized in various "made dishes," of which examples will be given further on, or they can always be put to good use in the soup kettle. It is surprising how many economies may be practiced in such ways and also in the table use of left-over portions of cooked meat if attention is given to the matter. Many of the recipes given in this bulletin involve the use of such left-overs. Others will suggest themselves or may be found in all the usual cookery books.

METHODS OF EXTENDING THE FLAVOR OF MEAT.

Common household methods of extending the meat flavor through a considerable quantity of material which would otherwise be lacking in distinctive taste are to serve the meat with dumplings, generally in the dish with it, to combine the meat with crusts, as in meat pies or meat rolls, or to serve the meat on toast and biscuits. Borders of rice, hominy, or mashed potatoes are examples of the same principles applied in different ways. By serving some preparation of flour, rice, hominy, or other food rich in starch with the meat we get a dish which in itself approaches nearer to the balanced ration than meat alone and one in which the meat flavor is extended through a large amount of the material.

Throughout the bulletin the measurements given in the recipes call for a level spoonful or a level cupful, as the case may be.

USE OF DUMPLINGS AND SIMILAR PREPARATIONS.

A number of recipes for meat dishes made with dumplings and similar preparations follow:

Meat Stew with Dumplings.

STEW.

5 pounds of a cheaper cut of beef.
4 cups of potatoes cut into small pieces.
¾ cup each of turnips and carrots cut into ½-inch cubes.
½ onion, chopped.
¼ cup of flour.
Salt and pepper.

Cut the meat into small pieces, removing the fat; try out the fat and brown the meat in it. When well browned, cover with boiling water, boil for five minutes and then cook in a lower temperature until the meat is done. If tender, this will require about three hours on the stove or five hours in the fireless cooker. Add carrots, turnips, onions, pepper, and salt during the last hour of cooking, and the potatoes fifteen minutes before serving. Thicken with the flour diluted with cold water. Serve with dumplings (see below). If this dish is made in the fireless cooker, the mixture must be reheated when the vegetables are put in. Such a stew may also be made of mutton. If veal or pork is used the vegetables may be omitted or simply a little onion used. Sometimes for variety the browning of the meat is dispensed with. When white meat, such as chicken, veal, or fresh pork, is used, the gravy is often made rich with cream or milk thickened with flour. The numerous minor additions which may be introduced give the great variety of such stews found in cookbooks.

DUMPLINGS.

2 cups flour.
4 teaspoonfuls baking powder.
¾ cup milk or a little more if needed.
½ teaspoonful salt.
2 teaspoonfuls butter.

Mix and sift the dry ingredients. Work in the butter with the tips of fingers, add milk gradually, roll out to a thickness of one-half inch and cut with biscuit cutter. In some countries it is customary to season the dumplings themselves with herbs, etc., or to stuff them with bread crumbs fried in butter instead of depending upon the gravy to season them.

A good way to cook dumplings is to put them in a buttered steamer over a kettle of hot water. They should cook from twelve to fifteen minutes. If it is necessary to cook them with the stew, enough liquid should be removed so that they may be placed upon the meat and vegetables.

Sometimes the dough is baked and served as biscuits over which the stew is poured. If the stew is made with chicken or veal it is generally termed a fricassee.

Ragout of Mutton with Farina Balls.

1½ pounds neck of mutton cut into small pieces.
1 tablespoonful butter.
1 tablespoonful flour.
1 onion.
1 carrot.
½ can peas.
2 cups hot water.
1 teaspoonful salt.
¼ teaspoonful pepper.
1 bay leaf.
Sprig parsley.
1 clove.

FARINA BALLS.

¼ cup farina.
1 cup milk.
½ teaspoonful salt.
⅛ teaspoonful pepper.
Onion juice.
Yolk 1 egg.

Put butter in frying pan. When melted add flour and brown. Add carrot and onion, cut in dice. Remove vegetables and add meat, searing well. To meat and vegetables add hot water and seasonings. Put in a suitable kettle, cover and simmer two hours. Add peas ten minutes before serving in a dish with farina balls made as follows:

Cook farina and milk in double boiler one hour. Add seasoning and well-beaten yolk. Stir well and cool. When cold roll into balls. Dip in egg and crumbs and fry in deep fat. Rice may be used in a similar way.

MEAT PIES AND SIMILAR DISHES.

Meat pies represent another method of combining flour with meat. They are ordinarily baked in a fairly deep dish the sides of which may or may not be lined with dough. The cooked meat, cut into small pieces, is put into the dish, sometimes with small pieces of vegetables, a gravy is poured over the meat, the dish is covered with a layer of dough, and then baked. Most commonly the dough is like that used for soda or cream-of-tartar biscuit, but sometimes shortened pastry dough, such as is made for pies, is used. This is especially the case in the fancy individual dishes usually called patties. Occasionally the pie is covered with a potato crust in which case the meat is put directly into the dish without lining the latter. Stewed beef, veal, and chicken are probably most frequently used in pies, but any kind of meat may be used, or several kinds in combination. Pork pies are favorite dishes in many rural regions, especially at hog-killing time, and when well made are excellent.

If pies are made from raw meat and vegetables longer cooking is needed than otherwise, and in such cases it is well to cover the dish with a plate, cook until the pie is nearly done, then remove the plate, add the crust, and return to the oven until the crust is lightly browned. Many cooks insist on piercing holes in the top crust of a meat pie directly it is taken from the oven.

Twelve O'clock Pie.

This is made with shoulder of mutton, boiled with carrot and onion, then cut up, mixed with potatoes separately boiled and cut up, and put into a baking dish. The crust is made by mixing smoothly mashed potatoes to which a tablespoonful of shortening has been added, with enough flour and water to make them roll out easily. A pie made of a pound of meat will require 5 or 6 small boiled potatoes, a cupful of mashed potatoes, and 8 or 10 tablespoonfuls of flour, and should be baked about twenty minutes in a hot oven. Salt, pepper, and other seasoning, as onion and carrot, may be added to taste. A teaspoonful of baking powder makes the crust lighter.

Meat and Tomato Pie.

This dish presents an excellent way of using up small quantities of either cold beef or cold mutton. If fresh tomatoes are used, peel and slice them; if canned, drain off the liquid. Place a layer of tomato in a baking dish, then a layer of sliced meat, and over the two dredge flour, pepper, and salt; repeat until the dish is nearly full, then put in an extra layer of tomato and cover the whole with a layer of pastry or of bread or cracker crumbs. When the quantity of meat is small, it may be "helped out" by boiled potatoes or other suitable vegetables. A few oysters or mushrooms improve the flavor, especially when beef is used. The pie will need to be baked from half an hour to an hour according to its size and the heat of the oven.

Meat and Pastry Rolls.

Small quantities of cold ham, chicken, or other meat may be utilized for these. The meat should be chopped fine, well seasoned, mixed with enough savory fat or butter to make it "shape," and formed into rolls about the size of a finger. A short dough (made, say, of a pint of flour, 2 tablespoonfuls of lard, 1 teaspoonful of baking powder, salt, and milk enough to mix) should be rolled thin, cut into strips, and folded about the meat rolls, care being taken to keep the shape regular. The rolls should be baked in a quick oven until they are a delicate brown color and served hot.

Meat Turnovers.

Almost any kind of chopped meat may be used in these, and if the quantity on hand is small may be mixed with potato or cooked rice. This filling should be seasoned to taste with salt and pepper, onion, or whatever is relished, and laid on pieces of short biscuit dough rolled thin and cut into circles about the size of an ordinary saucer. The edges of the dough should be moistened with white of egg, the dough then folded over the meat, and its edges pinched closely together. If desired, the tops of the turnovers may be brushed over with yolk of egg before they are placed in the oven. About half an hour's baking in a hot oven is required. Serving with a brown sauce (see p. 28) increases the flavor and moistens the crust.

MEAT WITH MACARONI AND OTHER STARCHY MATERIALS.

Macaroni cooked with chopped ham, hash made of meat and potatoes or meat and rice, meat croquettes—made of meat and some starchy materials like bread crumbs, cracker dust, or rice—are other familiar examples of meat combined with starchy materials. Pilaf, a dish very common in the Orient and well known in the United States, is of this character and easily made. When there is soup or soup stock on hand it can be well used in the pilaf.

Turkish Pilaf.

½ cup of rice.
¾ cup of tomatoes stewed and strained.
1 cup stock or broth.
3 tablespoonfuls of butter.

Cook the rice and tomatoes with the stock in a double boiler until the rice is tender, removing the cover after the rice is cooked if there is too much liquid. Add the butter and stir it in with a fork to prevent the rice from being broken. A little catsup or Chili sauce with water enough to make three-quarters of a cup may be substituted for the tomatoes. This may be served as a border with meat, or served separately in the place of a vegetable, or may make the main dish at a meal, as it is savory and reasonably nutritious.

Meat Cakes.

1 pound chopped veal.
¼ pound soaked bread crumbs.
2 tablespoonfuls savory fat or butter.
1 teaspoonful chopped onion.
1½ teaspoonfuls salt.
Dash of pepper.

Mix all the ingredients except the butter or fat and shape into small round cakes. Melt the fat in a baking pan and brown the cakes in it, first one side and then the other. Either cooked or raw veal may be used. In the case of raw meat the pan should be covered so that the heat may be retained to soften the meat.

Stew from Cold Roast.

This dish provides a good way of using up the remnants of a roast, either of beef or mutton. The meat should be freed from fat, gristle, and bones, cut into small pieces, slightly salted, and put into a kettle with water enough to nearly cover it. It should simmer until almost ready to break in pieces, when onions and raw potatoes, peeled and quartered, should be added. A little soup stock may also be added if available. Cook until the potatoes are done, then thicken the liquor or gravy with flour. The stew may be attractively served on slices of crisp toast.

MEAT WITH BEANS.

Dry beans are very rich in protein, the percentage being fully as large as that in meat. Dry beans and other similar legumes are usually cooked in water, which they absorb, and so are diluted before serving; on the other hand, meats by the ordinary methods of cooking are usually deprived of some of the water originally present—facts which are often overlooked in discussing the matter. Nevertheless, when beans are served with meat the dish is almost as rich in protein as if it consisted entirely of meat.

Pork and beans is such a well-known dish that recipes are not needed. Some cooks use a piece of corned mutton or a piece of corned beef in place of salt or corned pork or bacon or use butter or olive oil in preparing this dish.

In the Southern States, where cowpeas are a common crop, they are cooked in the same way as dried beans. Cowpeas baked with salt pork or bacon make an excellent dish resembling pork and beans, but of distinctive flavor. Cowpeas boiled with ham or with bacon are also well-known and palatable dishes.

Recipes are here given for some less common meat and bean dishes.

Mexican Beef.

The Mexicans have a dish known as "Chili con carne" (meat with Chili pepper), the ingredients for which one would doubtless have difficulty in obtaining except in the southwestern United States. However, a good substitute for it may be made with the foods available in all parts of the country. The Mexican recipe is as follows:

Remove the seeds from two Chili peppers, soak the pods in a pint of warm water until they are soft, scrape the pulp from the skin and add to the water. Cut two pounds of beef into small pieces and brown in butter or drippings. Add a clove of garlic and the Chili water. Cook until the meat is tender, renewing the water if necessary. Thicken the sauce with flour. Serve with Mexican beans either mixed with the meat or used as a border.

In the absence of the Chili peppers, water and Cayenne pepper may be used, and onions may be substituted for garlic. For the Mexican beans, red kidney beans either fresh or canned make a good substitute. If the canned beans are used they should be drained and heated in a little savory fat or butter. The liquid may be added to the meat while it is cooking. If the dried beans are used they should be soaked until soft, then cooked in water until tender and rather dry, a little butter or dripping and salt being used for seasoning or gravy. White or dried Lima beans may be used in a similar way.

Haricot of Mutton.

2 tablespoonfuls of chopped onions.
2 tablespoonfuls of butter or drippings.
2 cups of water, and salt and pepper.
1½ pounds of lean mutton or lamb cut into 2-inch pieces.

Fry the onions in the butter, add the meat, and brown; cover with water and cook until the meat is tender. Serve with a border of Lima beans, seasoned with salt, pepper, butter, and a little chopped parsley. Fresh, canned, dried, or evaporated Lima beans may be used in making this dish.

Roast Pork with Cowpeas.

For this dish a leg of young pork should be selected. With a sharp knife make a deep cut in the knuckle and fill the opening with sage, pepper, salt, and chopped onion. When the roast is half done scar the skin but do not cut deeper than the outer rind. When the meat is nearly cooked pour off the excess of fat and add a quart of *white* cowpeas which have been previously parboiled or "hulled" and cook slowly until quite done and the meat is brown. Apple sauce may be served with this dish.

MEAT SALADS.

Whether meat salads are economical or not depends upon the way in which the materials are utilized. If in chicken salad, for example, only the white meat of chickens especially bought for the purpose and only the inside stems of expensive celery are used, it can hardly be cheaper than plain chicken. But, if portions of meat left over from a previous serving are mixed with celery grown at home, they certainly make an economical dish, and one very acceptable to most persons. Cold roast pork or tender veal—in fact, any white meat can be utilized in the same way. Apples cut into cubes may be substituted for part of the celery; many cooks consider that with the apple the salad takes the dressing better than with the celery alone. Many also prefer to marinate (i. e., mix with a little oil and vinegar) the meat and celery or celery and apples before putting in the final dressing, which may be either mayonnaise or a good boiled dressing.

MEAT WITH EGGS.

Occasionally eggs are combined with meat, making very nutritious dishes. Whether this is an economy or not of course depends on the comparative cost of eggs and meat.

In general, it may be said that eggs are cheaper food than meat when a dozen costs less than 1½ pounds of meat, for a dozen eggs weighs about 1½ pounds and the proportions of protein and fat which they contain are not far different from the proportions of these nutrients in the average cut of meat. When eggs are 30 cents a dozen they compare favorably with round of beef at 20 cents a pound.

Such common dishes as ham and eggs, bacon or salt pork and eggs, and omelette with minced ham or other meat are familiar to all cooks.

Roast Beef with Yorkshire Pudding.

The beef is roasted as usual and the pudding made as follows:

YORKSHIRE PUDDING.

3 eggs.
1 pint milk.
1 cupful flour.
1 teaspoonful salt.

Beat the eggs until very light, then add the milk. Pour the mixture over the flour, add the salt, and beat well. Bake in hissing hot gem pans or in an ordinary baking pan for forty-five minutes, and baste with drippings from the beef. If gem pans are used, they should be placed on a dripping pan to protect the floor of the oven from the fat. Many cooks prefer to bake Yorkshire pudding in the pan with the meat; in this case the roast should be placed on a rack and the pudding batter poured on the pan under it.

Corned-Beef Hash with Poached Eggs.

A dish popular with many persons is corned-beef hash with poached eggs on top of the hash. A slice of toast is sometimes used under the hash. This suggests a way of utilizing the small amount of corned-beef hash which would otherwise be insufficient for a meal.

Housekeepers occasionally use up odd bits of other meat in a similar way, chopping and seasoning them and then warming and serving in individual baking cups with a poached or shirred egg on each.

Ham and Poached Eggs with Cream Sauce.

A more elaborate dish of meat and eggs is made by placing a piece of thinly sliced boiled ham on a round of buttered toast, a poached egg on the ham, and covering with a highly seasoned cream or a Hollandaise sauce. A slice of tongue may be used instead of the ham. If preferred, a well-seasoned and rather thick tomato sauce or curry sauce may be used.

STUFFING OR FORCEMEAT.

Another popular way to extend the flavor of meat over a large amount of food is by the use of stuffing or forcemeat (a synonym more common in England than in the United States). As it is impossible to introduce much stuffing into some pieces of meat even if the meat is cut to make a pocket for it, it is often well to prepare more than can be put into the meat and to cook the remainder in the pan beside the meat. Some cooks cover the extra stuffing with buttered paper while it is cooking and baste it at intervals.

Some recipes for meat dishes of this character follow, and others will be found in cookbooks.

Mock Duck.

Mock duck is made by placing on a round steak a stuffing of bread crumb well seasoned with chopped onions, butter, chopped suet or dripping, salt, pepper, and a little sage, if the flavor is relished. The steak is then rolled around the stuffing and tied with a string in several places. If the steak seems tough, the roll is steamed or stewed until tender before roasting in the oven until brown. Or it may be cooked in a casserole or other covered dish, in which case a cupful or more of water or soup-stock should be poured around the meat. Mock duck is excellent served with currant or other acid jelly.

Mock Wild Duck.

1 flank steak, or
1½ pounds round steak cut ½ inch thick.
2 lamb kidneys.
¼ cup butter or drippings.
½ cup cracker crumbs.
1 tablespoonful minced onion.
Salt, pepper, and powdered thyme, sage, and savory.
2 tablespoonfuls flour.
1 tablespoonful sugar.
3 cupfuls water or stock.

Trim the kidneys of all fat, cords, and veins. Cut into small pieces and spread evenly over one side of the steak together with the crumbs, onion, and seasonings. Roll and tie with a cord. Brown the roll in fat, then remove and make a gravy by heating the flour in the fat and adding three cupfuls of stock or water and the sugar. Put the meat into the gravy and cook slowly until tender in a covered baking dish, a steamer, or a fireless cooker. If steamed or cooked in a fireless cooker, the roll should be browned in the oven before serving.

Veal or Beef Birds.

A popular dish known as veal or beef birds or by a variety of special names is made by taking small pieces of meat, each just large enough for an individual serving, and preparing them in the same way as the mock duck is prepared.

Sometimes variety is introduced by seasoning the stuffing with chopped olives or tomato. Many cooks prepare their "birds" by browning in a little fat, then adding a little water, covering closely and simmering until tender.

UTILIZING THE CHEAPER CUTS OF MEAT IN PALATABLE DISHES.

When the housekeeper attempts to reduce her meat bill by using the less expensive cuts, she commonly has two difficulties to contend with—toughness and lack of flavor. It has been shown how prolonged cooking softens the connective tissues of the meat. Pounding the meat and chopping it are also employed with tough cuts, as they help to break the muscle fibers. As for flavor, the natural flavor of meat even in the least desirable cuts may be developed by careful cooking, notably by browning the surface, and other flavors may be given by the addition of vegetables and seasoning with condiments of various kinds.

Methods of preparing inexpensive meat dishes will be discussed and practical directions for them will be given in the following sections. As often happens, two or three methods may be illustrated by the same dish, but the attempt has been made to group the recipes according to their most salient feature.

PROLONGED COOKING AT LOW HEAT.

Meat may be cooked in water in a number of ways without being allowed to reach the boiling point. With the ordinary kitchen range this is accomplished by cooking on the cooler part of the stove rather than on the hottest part, directly over the fire. Experience with a gas stove, particularly if it has a small burner known as a "simmerer," usually enables the cook to maintain temperatures which are high enough to sterilize the meat if it has become accidentally contaminated in any way and to make it tender without hardening the fibers. The double boiler would seem to be a neglected utensil for this purpose. Its contents can easily be kept up to a temperature of 200° F., and nothing will burn. Another method is by means of the fireless cooker. In this a high temperature can be maintained for a long time without the application of fresh heat. Still another method is by means of a closely covered baking dish. Earthenware dishes of this kind suitable for serving foods as well as for cooking are known as casseroles. For cooking purposes a baking dish covered with a plate or a bean jar covered with a saucer may be substituted. The Aladdin oven has long been popular for the purpose of preserving temperatures which are near the boiling point and yet do not reach it. It is a thoroughly insulated oven which may be heated either by a kerosene lamp or a gas jet.

In this connection directions are given for using some of the toughest and least promising pieces of meat.

Stewed Shin of Beef.

4 pounds of shin of beef.
1 medium-sized onion.
1 whole clove and a small bay leaf.
1 sprig of parsley.
1½ tablespoonfuls of flour.
1 small slice of carrot.
½ tablespoonful of salt.
⅛ teaspoonful of pepper.
2 quarts of boiling water.
1½ tablespoonfuls of butter or savory drippings.

Have the butcher cut the bone in several pieces. Put all the ingredients but the flour and butter into a stewpan and bring to a boil. Set the pan where the liquid will just simmer for six hours, or after boiling for five or ten minutes, put all into the fireless cooker for eight or nine hours. With the butter, flour, and one-half cupful of the clear soup from which the fat has been removed, make a brown sauce (see p. 28); to this add the meat and the marrow removed from the bone. Heat and serve. The remainder of the liquid in which the meat has been cooked may be used for soup.

Boiled Beef with Horse-radish Sauce.

Plain boiled beef may also be served with horse-radish sauce, for which a recipe is given on page 27, and makes a palatable dish. A little chopped parsley sprinkled over the meat when served is considered an improvement by many persons. For the sake of variety the meat may be browned like pot roast before serving.

Scotch Broth.

3 pounds mutton.
2 tablespoonfuls of pearl barley.
2 tablespoonfuls of minced onion.
2 tablespoonfuls of minced turnip.
2 tablespoonfuls of minced carrot.
2 tablespoonfuls of minced celery.
2 tablespoonfuls of salt.
1 teaspoonful of pepper.
1 tablespoonful of minced parsley.
3 quarts cold water.

Remove the bones and all the fat from the mutton, cut the meat into small pieces and put it into a stewpan with the water, chopped vegetables, barley, and all the seasoning excepting the parsley. It will be found convenient to tie the bones in a piece of thin white cloth before adding them to the other ingredients. Bring the stew to a boil, quickly skim it and allow it to simmer for three hours, thicken with the flour, and add the chopped parsley.

Stuffed Heart.

Wash the heart thoroughly inside and out, stuff with the following mixture, and sew up the opening: One cup broken bread dipped in fat and browned in the oven, 1 chopped onion, and salt and pepper to taste.

Cover the heart with water and simmer until tender or boil ten minutes and set in the fireless cooker for six or eight hours. Remove from the water about one-half hour before serving. Dredge with flour, pepper, and salt, or sprinkle with crumbs and bake until brown.

Braised Beef, Pot Roast, and Beef à la Mode.

The above names are given to dishes made from the less tender cuts of meat. They vary little either in composition or method of preparation. In all cases the meat is browned on the outside to increase the flavor and then cooked in a small amount of water in a closely covered kettle or other receptacle until tender. The flavor of the dish is secured by browning the meat and by the addition of the seasoning vegetables. Many recipes suggest that the vegetables be removed before serving and the liquid be thickened. As the vegetables are usually extremely well-seasoned by means of the browned fat and the extracts of the meat, it seems unfortunate not to serve them.

Of course, the kind, quality, and shape of the meat all play their part in the matter. Extra time is needed for meats with a good deal of sinew and tough fibers such as the tough steaks, shank cuts, etc.; and naturally a fillet of beef, or a steak from a prime cut, will take less time than a thick piece from the shin. Such dishes require more time and perhaps more skill in their preparation and may involve more expense for fuel than the more costly cuts, which like chops or tender steaks may be quickly cooked, but to the epicure, as well as to the average man, they are palatable when rightly prepared.

Bean-Pot Roast.

3 pounds mutton (shoulder), or
3 pounds round, or chuck steak.
1 cup carrots cut into small pieces.
1 cup potatoes cut into small pieces.
½ cup sliced onion.

Cover the meat with boiling water. Place the cover on the bean pot and let the meat cook in a moderate oven for two hours; then add the vegetables cut in half-inch cubes, with 2 teaspoonfuls salt; cook until the vegetables are tender, which will require about one hour; then serve, pouring a sauce over the meat, made from 1 cup of the liquid in which the meat was cooked, thickened with 2 tablespoonfuls of flour.

Hungarian Goulash.

2 pounds top round of beef.
A little flour.
2 ounces salt pork.
2 cups tomatoes.
1 stalk celery.
1 onion.
2 bay leaves.
6 whole cloves.
6 peppercorns.
1 blade mace.

Cut the beef into 2-inch pieces and sprinkle with flour; fry the salt pork until light brown; add the beef and cook slowly for about thirty-five minutes, stirring occasionally. Cover with water and simmer about two hours; season with salt and pepper or paprika.

From the vegetables and spices a sauce is made as follows: Cook in sufficient water to cover for twenty minutes; then rub through a sieve, and add to some of the stock in which the meat was cooked. Thicken with flour, using 2 tablespoonfuls (moistened with cold water) to each cup of liquid, and season with salt and paprika.

Serve the meat on a platter with the sauce poured over it. Potatoes, carrots, and green peppers cooked until tender, and cut into small pieces or narrow strips, are usually sprinkled over the dish when served, and noodles may be arranged in a border upon the platter.

Goulash is a Hungarian dish which has come to be a favorite in the United States.

CASSEROLE COOKERY.

A casserole is a heavy earthenware dish with a cover. A substitute for it can easily be improvised by using any heavy earthenware dish with a heavy plate for the cover. A casserole presentable enough in appearance to be put on the table serves the double purpose of baking and serving dish.

A suitable cut of beef or veal, and it may well be one of the cheaper cuts, as the long, slow cooking insures tenderness, may be cooked in a casserole.

Poultry and other meats besides beef or veal can be cooked in this manner. Chicken cooked in a casserole, which is a favorite and expensive dish in good hotels and restaurants, may be easily prepared in the home, and casserole cookery is to be recommended for a tough chicken.

The heat must be moderate and the cooking must occupy a long time. Hurried cooking in a casserole is out of the question. If care is taken in this particular, and suitable seasonings are used, few who know anything of cooking should go astray.

Chopped meat also may be cooked in a casserole and this utensil is particularly useful for the purpose, because the food is served in the same dish in which it is cooked and may easily be kept hot, a point which is important with chopped meats, which usually cool rapidly.

Casserole Roast.

3 or 4 pounds of round or rump of beef.
A slice of salt pork.
A few peppercorns.
One-fourth each of a carrot, a turnip, an onion, and a head of celery cut into small pieces.

Try out the pork. Brown the meat on both sides in the fat. Put in a casserole with the vegetables around it, add 2 cupfuls of water or stock. Cover and cook in a hot oven three hours, basting occasionally. A sauce or gravy can be made with water, flour, and some of the juice left in the casserole.

Casserole or Italian Hash.

Boil one-fourth pound of macaroni, drain and put into a buttered casserole, add a little butter and grated cheese. Push the macaroni to the sides of the dish and fill the center with chopped cooked meat seasoned to suit the taste of the family. A little sausage gives a good flavor to this dish. Place in the oven until hot throughout and serve.

A very good modification of this is made by using raw instead of cooked meat. For this one-half pound of round steak is sufficient for a family of six. This should be cut into small pieces, browned, and cooked until tender in water with the onions and other seasonings. An hour before the cooking is complete, add one-half can of tomatoes. Before serving, the meat may be mixed with the sauce, and the whole is poured over the macaroni.

MEAT COOKED WITH VINEGAR.

Dishes of similar sort as regards cooking, but in which vinegar is used to give flavor as well as to soften the meat and make it tender, are the following:

Sour Beef.

Take a piece of beef from the rump or the lower round, cover with vinegar or with a half-and-half mixture of vinegar and water, add sliced onion, bay leaves, and a few mixed whole spices and salt. Allow to stand a week in winter or three or four days in summer; turn once a day and keep covered. When ready to cook, brown the meat in fat, using an enameled iron pan, strain the liquid over it and cook until tender; thicken the gravy with flour or ginger snaps (which may be broken up first), strain it, and pour over the sliced meat. Some cooks add cream.

Sour Beefsteak.

Round steak may be cooked in water in which there is a little vinegar, or if the time is sufficient, it may be soaked for a few hours in vinegar and water and then cooked in a casserole or in some similar way.

POUNDED MEAT.

Pounding meat before cooking is an old-fashioned method of making it tender. but while it has the advantage of breaking down the tough tissues it has the disadvantage of being likely to drive out the juices and with them the flavor. A very good way of escaping this difficulty is pounding flour into the meat; this catches and retains the juices. Below are given the recipes for two palatable dishes in which this is done:

Farmer Stew.

Pound flour into both sides of a round steak, using as much as the meat will take up. This may be done with a meat pounder or with the edge of a heavy plate. Fry in drippings, butter, or other fat in a Scotch bowl, or if more convenient in an ordinary iron kettle or a frying pan; then add water enough to cover it. Cover the dish very tightly so that the steam can not escape and allow the meat to simmer for two hours or until it is tender. One advantage of this dish is that ordinarily it is ready to serve when the meat is done as the gravy is already thickened. However, if a large amount of fat is used in the frying, the gravy may not be thick enough and must be blended with flour.

Spanish Beefsteak.

Take a piece of round steak weighing 2 pounds and about an inch thick; pound until thin, season with salt and Cayenne pepper, cover with a layer of bacon or salt pork, cut into thin slices, roll and tie with a cord. Pour around it half a cupful of milk and half a cupful of water. Place in a covered baking dish and cook two hours, basting occasionally.

CHOPPED MEAT.

Chopping meat is one of the principal methods of making tough and inexpensive meat tender, i. e., dividing it finely and thus cutting the connective tissue into small bits. Such meats have another advantage in that they may be cooked quickly and economically.

In broiling chopped meat the fact should be kept in mind that there is no reason why it should not be cooked like the best and most expensive tenderloin. The only reason that ever existed for difference in treatment was the toughness of the connective tissue, and this feature has been overcome by the chopping. The ideal to be reached in broiling steak is to sear the surface very quickly, so that the juices which contain the greater part of the flavoring of the meat shall be kept in, and then to allow the heat to penetrate to the inside until the whole mass is cooked to the taste of the family. To pass the point where the meat ceases to be puffy and juicy and becomes flat and hard is very undesirable, as the palatability is then lost. Exactly the same ideal should be kept in mind in broiling chopped meat. If this were always done, hard, compact, tasteless balls or cakes of meat would be served less often. To begin with, the broiler should be even more carefully greased than for a whole steak. This makes it possible to form the balls or cakes of chopped meat with very little pressure without running the risk of having them pulled to pieces by adhering to the wires of the broiler. They should be heated on both sides even more quickly than the steak, because the chopping has provided more ways of escape for the juice, and these openings should be sealed as soon as possible. The interior should be cooked to the taste of the family just as the steak is.

In regard to broiling it may incidentally be noted that housekeepers often make themselves unnecessary work when broiling under gas by allowing the juice from steaks or meat balls to drop into the large pan under the rack. A smaller pan set in the larger one may be made to catch all the juice and fat and is much easier to wash. It serves also to economize the gravy.

Chopped raw meat of almost any kind can be very quickly made into a savory dish by cooking it with water or with water and milk for a short time, then thickening with butter and flour, and adding different seasonings as relished, either pepper and salt alone, or onion juice, celery, or tomato. Such a dish may be made to "go further" by serving it on toast or with a border of rice or in some similar combination.

Tough Portions of Porterhouse Steak.

Before speaking of the cooking of the cuts that lack tenderness throughout, it may be well to refer to the fact that the flank end of the porterhouse is to be classed with the toughest of cuts and with those which, when cooked alone, are with difficulty made tender even by long heating. Mock duck, which is commonly made out of flank steak, can be rendered tender enough to be palatable only by long steaming or cooking in water (see p. 19) and yet people quite generally broil this part of the steak with the tenderloin and expect it to be eaten. The fact is that to broil this part of the porterhouse steak is not good management. It is much more profitable to put it into the soup kettle or to make it into a stew. In families where most of the members are away during the day the latter is a good plan, for the end of a steak makes a good stew for two or three people. This may be seasoned with vegetables left from dinner, or two or three olives cut up in gravy will give a very good flavor; or a few drops of some one of the bottled meat sauces, if the flavor is relished, or a little Chili sauce may be added to the stew. But if the tough end of a porterhouse is needed with the rest, a good plan is to put it through a meat grinder, make it into balls, and broil it with the tender portions. Each member of the family can then be served with a piece of the tenderloin and a meat ball. If the chopped meat is seasoned with a little onion juice, grated lemon rind, or chopped parsley, a good flavor is imparted to the gravy.

Hamburg Steak.

This name is commonly given to inexpensive cuts of beef chopped, seasoned a little, shaped into small balls or into one large thin cake, and quickly broiled in the way that a tender steak would be. Owing to the quick cooking much of the natural flavor of the meat is developed and retained. The fact should be kept in mind that Hamburg steak must be made from fresh, well-ground meat. It is much safer to chop the meat at home, as chopped meat spoils very quickly. Much depends, too, upon browning it sufficiently to bring out the flavors. Many cooks think that Hamburg steak is improved if the meat is mixed with milk before it is cooked.

In some parts of the country, and particularly in some of the Southern States, two kinds of beef are on sale One is imported from other parts of the country and is of higher price. The other, known locally as "native beef," is sometimes lacking in flavor and in fat and is usually tougher. Southern native beef such as is raised in Florida is almost invariably, however, of extremely good flavor, due presumably to the feed or other conditions under which it is raised. By chopping such meat and cooking it as Hamburg steak, a dish almost as palatable as the best cuts of the more expensive beef may be obtained. In such cases, however, it is desirable because of the low percentage of fat to add suet or butter to the meat. The reason for this is that in the cooking the water of the juice when unprotected by fat evaporates too quickly and leaves the meat dry. This may be prevented by adding egg as well as fat, for the albumen of the egg hardens quickly and tends to keep in the juices. The proportion should be 1 egg to 1½ pounds of meat.

Savory Rolls.

Savory rolls in great variety are made out of chopped meat either with or without egg. The variety is secured by the flavoring materials used and by the sauces with which the baked rolls are served. A few recipes will be given below. While these definite directions are given it should be remembered that a few general principles borne in mind make recipes unnecessary and make it possible to utilize whatever may happen to be on hand. Appetizing rolls are made with beef and pork mixed. The proportion varies from two parts of beef and one of pork to two of pork and one of beef. The rolls are always improved by laying thin slices of salt pork or bacon over them, which keep the surface moistened with fat during the roasting. These slices should be scored on the edge, so that they will not curl up in cooking. The necessity for the salt pork is greater when the chopped meat is chiefly beef than when it is largely pork or veal. Bread crumbs or bread moistened in water can always be added, as it helps to make the dish go farther. When onions, green peppers, or other vegetables are used, they should always be thoroughly cooked in fat before being put in the roll, for usually they do not cook sufficiently in the length of time it takes to cook the meat. Sausage makes a good addition to the roll, but it is usually cheaper to use unseasoned pork meat with the addition of a little sage.

Cannelon of Beef.

This dish is prepared by making chopped beef into a roll and baking it wrapped in a buttered paper, a method designed to keep in the steam and so insure a moist, tender dish. The paper must be removed before serving. The roll should be basted occasionally with butter and water or drippings and water. In preparing the roll an egg may be added for each pound and a half of meat, and chopped parsley, onion juice, lemon peel, or finely chopped green peppers make good seasoning. A thickened gravy may be made from the drippings, the liquid used being either water or tomato juice (see p. 28).

Strips of pork laid on the roll may be substituted for the buttered paper and basting.

Filipino Beef.

1 pound round beef.
½ pound lean fresh pork.
1 small onion.
1 green pepper.
1 teaspoonful of salt.
1 cup of soft stale bread crumbs.
1 egg.
2 cups of stewed tomatoes.
2 slices of bacon.
2 tablespoonfuls of butter.
4 tablespoonfuls of flour.

Remove the seeds from the pepper and put it through the meat grinder with the meats and the onion. Add crumbs, egg, and salt. Make into a roll, place in a shallow baking dish, pour the strained tomatoes around it, put the bacon on top, and bake forty minutes, basting with the tomatoes. Thicken the gravy with the flour cooked in the butter. A little seasoning such as a bit of bay leaf, a clove, and a small piece of onion improves the tomato sauce. As the pepper and onion are not likely to be cooked as soon as the meat, it is well to fry them in a little fat before adding to the other ingredients.

This dish will serve 6 to 8 people. When the meat is 20 cents a pound and every other item is valued at usual town market prices, the dish costs about 50 cents. If the meat costs only 10 cents per pound and vegetables from the garden are used the initial cost of the dish will be small. Since no vegetable except potatoes or rice need be served with this dish, it may be said to answer the purpose of both meat and vegetable.

Mock Rabbit.

½ pound round steak, and
1 pound sausage;
or
1 pound round steak, and
½ pound sausage meat.
3 slices of bread moistened with water.
1 egg.
1 onion.
¼ pound salt pork.
Pepper and salt.

Chop the meat. Chop the onion and cook (but do not brown) it in the fat tried out of a small portion of the pork. Add the bread and cook a few minutes. When this is cool, mix all the ingredients and form into a long round roll. The surface can easily be made smooth if the hand is wet with cold water. Lay the remaining pork cut in thin slices on top and bake forty minutes in a hot oven. The sausage may be omitted if desired and other seasoning used.

Veal Loaf.

3 pounds veal.
1 pound salt pork.
6 soda crackers rolled fine.
3 eggs well beaten.
¼ teaspoonful pepper.
½ teaspoonful salt.

Chop the meat mixed with the other ingredients, shape, and bake three hours, basting occasionally with pork fat. Use one-fourth cut of fat for this purpose. If the roll is pierced occasionally the fat will penetrate more effectually. Veal loaf may also be cooked in bread pans. Some persons cook the veal before chopping.

DEVELOPING AND IMPROVING FLAVOR OF MEAT.

The typical meat flavors are very palatable to most persons, even when they are constantly tasted, and consequently the better cuts of meat in which they are well developed can be cooked and served without attention being paid especially to flavor. Careful cooking aids in developing the natural flavor of some of the cheaper cuts, and such a result is to be sought wherever it is possible. Browning also brings out flavors agreeable to most palates. Aside from these two ways of increasing the flavor of the meat itself there are countless ways of adding flavor to otherwise rather tasteless meats. The flavors may be added in preparing the meat for cooking, as in various seasoned dishes already described, or they may be supplied to cooked meat in the form of sauces.

RETAINING NATURAL FLAVOR.

As has already been pointed out, it is extremely difficult to retain the flavor-giving extractives in a piece of meat so tough as to require prolonged cooking. It is sometimes partially accomplished by first searing the exterior of the meat and thus preventing the escape of the juices. Another device, illustrated by the following recipe, is to let them escape into the gravy which is served with the meat itself. A similar principle is applied when roasts are basted with their own juice.

Round Steak on Biscuits.

Cut round steak into pieces about one-half inch square, cover with water and cook it at a temperature just below the boiling point until it is tender, or boil for five minutes, and while still hot put into the fireless cooker and leave it for five hours. Thicken the gravy with flour mixed with water, allowing 2 level tablespoonfuls to a cup of water. Pour the meat and gravy over split baking-powder biscuits so baked that they have a large amount of crust.

FLAVOR OF BROWNED MEAT OR FAT.

Next to the unchanged flavor of the meat itself comes the flavor which is secured by browning the meat with fat. The outside slices of roast meat have this browned flavor in marked degree. Except in the case of roasts, browning for flavor is usually accomplished by heating the meat in a frying pan in fat which has been tried out of pork or in suet or butter. Care should be taken that the fat is not scorched. The chief reason for the bad opinion in which fried food is held by many is that it almost always means eating burned fat. When fat is heated too high it splits up into fatty acids and glycerin, and from the glycerin is formed a substance (acrolein) which has a very irritating effect upon the mucous membrane. All will recall that the fumes of scorched fat make the eyes water. It is not surprising that such a substance, if taken into the stomach, should cause digestive disturbance. Fat in itself is a very valuable food, and the objection to fried foods because they may be fat seems illogical. If they supply burned fat there is a good reason for suspicion. Many housekeepers cook bacon in the oven on a wire broiler over a pan and believe it more wholesome than fried bacon. The reason, of course, is that thus cooked in the oven there is less chance for the bacon becoming impregnated with burned fat. Where fried salt pork is much used good cooks know that it must not be cooked over a very hot fire, even if they have never heard of the chemistry of burned fat. The recipe for bean-pot roast (p. 21) and other similar recipes may be varied by browning the meat or part of it before covering with water. This results in keeping some of the natural flavoring within the meat itself and allowing less to go into the gravy. The flavor of veal can be very greatly improved in this way.

The following old-fashioned dishes made with pork owe their savoriness chiefly to the flavor of browned fat or meat:

Salt Pork with Milk Gravy.

Cut salt or cured pork into thin slices. If very salt, cover with hot water and allow it to stand for ten minutes. Score the rind of the slices and fry slowly until they are a golden brown. Make a milk gravy by heating flour in the fat that has been tried out, allowing 2 tablespoonfuls of fat and 2 tablespoonfuls of flour to each cup of milk. This is a good way to use skim milk, which is as rich in protein as whole milk. The pork and milk gravy served with boiled or baked potatoes makes a cheap and simple meal, but one that most people like very much. Bacon is often used in place of salt pork in making this dish.

Fried Salt Pork with Salt Codfish or "Salt-fish Dinner."

½ pound salt pork.
1 pound codfish.
2 cups of milk (skim milk will do).
4 tablespoonfuls flour.
A speck of salt.

Cut the codfish into strips, soak in lukewarm water and then cook in water until tender but do not allow the water to come to the boiling point except for a very short time as prolonged boiling may make it tough. Cut the pork into one-fourth inch slices and cut several gashes in each piece. Fry very slowly until golden brown, and remove, pouring off the fat. Out of 4 tablespoonfuls of the fat, the flour, and the milk make a white sauce. Dish up the codfish with pieces of pork around it and serve with boiled potatoes and beets. Some persons serve the pork, and the fat from it, in a gravy boat so it can be added as relished.

FLAVORING VEGETABLES, HERBS, SPICES, ETC.

Many flavorings are used in meat dishes, some of which are familiar to all cooks—onions, carrots, turnips, and garlic being perhaps the most widely known. Butter, too, may be regarded as one of the most common seasonings, and of course makes the dish richer. Meat extract is also used for flavoring many meat dishes and other foods, as are also, though less commonly, similar extracts made from clams or other "sea food." The following list includes these with various others, a number of which it is convenient to keep always on hand: Onions, carrots, green peppers, parsnips, turnips, tomatoes, fresh, canned or dried; celery tops and parsley, either fresh or dried; sage, savory, thyme, sweet marjoram, bay leaf, garlic, lemon rind, vinegar, capers, pickles, olives, currant jelly, curry powder, cloves, pepper corns, celery seed, meat extract, Chili sauce, pepper sauce, or some similar hot or sharp sauce, and some kind of good commercial meat sauce. Some hints regarding the use of such flavorings follow:

Flavor of fried vegetables.—Most of the stews, soups, braised meats, and pot roasts are very much improved if the flavoring vegetables which they contain, such as carrots, turnips, onions, celery, or green peppers, are fried in a little fat before being cooked with the meat. This need not complicate the preparation of the meat or increase the number of utensils used, for the meat itself is usually seared over in fat, and the vegetables can be cooked in the same fat before the browning of the meat.

Onion juice.—Cookbooks usually say that onion juice should be extracted by cutting an onion in two and rubbing the cut surface against a grater. Considering how hard it is to wash a grater, this method has its drawbacks. Small amounts of juice may be obtained in the following simpler way: Peel the onion and extract a few drops of juice by pressing one side with the dull edge of a knife.

Green peppers.—The flavor of green peppers gives an acceptable variety. The seed should always be removed. The peppers should be chopped and added to chopped meat or other meat dishes. Meat mixed with bread crumbs may be baked in the pepper shells and the stuffed peppers served as a separate dish.

Parsley.—It is easy to raise parsley by growing it in a pot in the kitchen window and thus to have it always on hand fresh, or the leaves may be kept for a long time if sealed up in a fruit jar and stored in a cool place. Parsley, mint, and celery tops may all be dried, rubbed into fine bits, and kept in air-tight jars. Recipes usually say to chop fresh parsley with a sharp knife on a board. But a board is a hard thing to wash and a plate serves the purpose quite as well.

Bay leaf.—Bay leaf is one of the best and at the same time one of the most-abused flavors. In small quantities it gives a very pleasant flavor to soups and gravies, but in large quantities it gives a rank resin-like taste. Remember that half of a bay leaf is the allowance for 3 quarts of soup stock. This will indicate how small a quantity should be used for the portion of gravy usually served at a meal. With this precaution in mind, bay leaf may be recommended as a flavoring for many sauces, particularly tomato sauce.

A kitchen bouquet.—A "bouquet" such as is often referred to in recipes may be made as follows: A sprig each of parsley, savory, and thyme, one small leaf of sage, and a bay leaf. This will flavor 1 gallon of soup when cooked in it for an hour and should not remain in it longer.

Horse-radish.—Horse-radish, like mustard, is more often served with meat than used to flavor it during cooking. A very palatable sauce, especially good with boiled beef, is made by adding grated horse-radish and a little vinegar to a little whipped cream, or as follows: Thicken milk with cracker crumbs by heating them together in a double boiler, using 3 tablespoonfuls of cracker crumbs to 1½ cups of milk. Add one-third of a cup of grated horse-radish, 3 tablespoonfuls of butter, and ½ teaspoonful of salt; or thicken with butter and flour some of the water in which the meat was boiled, add a generous quantity (1 or 2 tablespoonfuls) of grated horse-radish, boil a short time, and serve. This recipe is the most usual in German homes where the sauce is a favorite.

Acid flavoring.—Vinegar, lemon juice, and sour jelly, like currant, are often used to flavor the thick gravies which are a part of meat stew or which are served with it. Vinegar is an old-fashioned relish which was often added to bacon or salt pork and greens, pork and beans, corned beef and cabbage, and similar dishes. These flavors combine well with that of brown flour, but not with onions or other vegetables of strong flavor. The idea that vinegar used in small quantities is unwholesome seems to be without foundation.

Pickles.—Chopped pickles are sometimes added to the gravy served with boiled mutton. They are cheaper than capers and serve somewhat the same purpose. Chopped pickles are also very commonly used in sauces for fish and in many others to give a distinctive flavor.

Olives.—Chopped olives also make a welcome variety in meat sauce, and are not expensive if they are bought in bulk. They will not spoil if a little olive oil is poured on the top of the liquor in which they are kept. This liquor should always completely cover them.

Chili sauce, commercial meat sauces, etc.—Recipes often may be varied by the addition of a little Chili sauce, tomato catsup, or a commercial meat sauce. These may be called emergency flavors and used when it is not convenient to prepare other kinds of gravies.

Sausage.—A little sausage or chopped ham may be used in chopped beef.

Curry powder.—This mixture of spices which apparently originated in India, but which is now a common commercial product everywhere, is a favorite flavoring for veal, lamb, or poultry. The precaution mentioned in connection with bay leaves, however, should be observed. A small amount gives a good flavor. It is usually used to season the thick sauces with which meats are served or in which they are allowed to simmer. While the term "curry" is usually employed to describe a particular mixture of spices made up for the trade, it has another meaning. The words "curry" or "curried" are sometimes used to describe highly seasoned dishes of meat, eggs, or vegetables prepared by methods that have come from India or other parts of the East.

India Curry.

1½ pounds veal.
½ cup of butter or drippings.
2 onions or less.
½ tablespoonful curry or less.

Brown meat either without fat or with very little and cut into small pieces.

Fry the onions in the butter, remove them, add the meat and curry powder. Cover the meat with boiling water and cook until tender. Serve with a border of rice. This dish is so savory that it can be made to go a long way by serving with a large amount of rice. The two onions and one-half tablespoonful of curry powder are the largest amount to be used. Many persons prefer less of each.

In preparing the rice for this dish perhaps no better method can be given than that in an earlier bulletin of this series:[a]

"Wash 1 cupful of rice in several waters, rubbing the grains between the hands to remove all the dirt. Put the washed rice in a stewpan with 2½ cupfuls of water and 1 teaspoonful of salt. Cover and place where the water will boil. Cook for twenty minutes, being careful not to let it burn. At the end of this time put the stewpan on a tripod or ring and cover the rice with a fold of cheese cloth. Let it continue to cook in this manner an hour, then turn into a hot vegetable dish. The rice will be tender, dry and sweet, and each grain will separate. During the whole process of cooking the rice must not be stirred. If a tablespoonful of butter is cut up and scattered over the rice when it has cooked twenty minutes the dish will be very much improved."

The butter is not necessary when the rice is served with India curry but may be included in dishes where less fat is used.

Curry of Veal.

2 tablespoonfuls butter or drippings.
1½ pounds veal.
½ onion, chopped.
1 pint milk.
1 tablespoonful flour.
1 teaspoonful curry powder.
Salt and pepper.

Fry the onions in the butter or drippings, remove, and fry the veal until it is brown. Transfer the meat to the double boiler, cover with milk and cook until the meat is tender. Add the curry powder a short time before the meat is done and thicken the milk with flour before serving.

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[a] U. S. Dept. Agr., Farmers' Bul. 256, p. 38.

SAUCES.

The art of preparing savory gravies and sauces is more important in connection with the serving of the cheaper meats than in connection with the cooking of the more expensive.

There are a few general principles underlying the making of all sauces or gravies, whether the liquid used is water, milk, stock, tomato juice, or some combination of these. For ordinary gravy 2 level tablespoonfuls of flour or 1½ tablespoonfuls of cornstarch or arrowroot is sufficient to thicken a cupful of liquid. This is true excepting when, as in the recipe on page 17, the flour is browned. In this case about one-half tablespoonful more should be allowed, for browned flour does not thicken so well as unbrowned. The fat used may be butter or the drippings from the meat, the allowance being 2 tablespoonfuls to a cup of liquid.

The easiest way to mix the ingredients is to heat the fat, add the flour, and cook until the mixture ceases to bubble, and then to add the liquid. This is a quick method and by using it there is little danger of getting a lumpy gravy. Many persons, however, think it is not a wholesome method and prefer the old-fashioned one of thickening the gravy by means of flour mixed with a little cold water. The latter method is of course not practicable for brown gravies.

Considering the large amount of discussion about the digestibility of fried food and of gravies made by heating flour in fat, a few words on the subject at this point may not be out of order. It is difficult to see how heating the fat before adding the flour can be unwholesome, unless the cook is unskillful enough to heat the fat so high that it begins to scorch. Overheated fat, as has already been pointed out, contains an acrid irritating substance called "acrolein," which may be readily considered to be unwholesome. It is without doubt the production of this body by overheating which has given fried food its bad name. Several ways of varying the flavor of gravies and sauces were suggested in the preceding section. One other should be especially mentioned here.

The flavor of browned flour.—The good flavor of browned flour is often overlooked. If flour is cooked in fat until it is a dark brown color a distinctive and very agreeable flavor is obtained. This flavor combines very well with that of current jelly, and a little jelly added to a brown gravy is a great improvement. The flavor of this should not be combined with that of onions or other highly flavored vegetables. A recipe for a dish which is made with brown sauce follows.

Mock Venison.

Cut cold mutton into thin slices and heat in a brown sauce made according to the following proportions:

2 tablespoonfuls butter.
2 tablespoonfuls flour.
1 tablespoonful of bottled meat sauce (whichever is preferred.)
1 tablespoonful red-currant jelly.
1 cupful water or stock.

Brown the flour in the butter, add the water or stock slowly, and keep stirring. Then add the jelly and meat sauce and let the mixture boil up well.

SUMMARY.

The nutritive value of meat, the relative digestibility of different kinds and cuts cooked in various ways, the losses sustained in different methods of cooking, and related questions which have to do with the use of meat as food, have been studied as a part of the nutrition investigations of the Office of Experiment Stations. Many investigators have contributed to the enterprise and special methods have been followed. In the study of some of the problems the respiration calorimeter has been used and results have been obtained important from a scientific as well as from a practical standpoint.

Studies of the food habits of peoples living in the temperate and warmer regions of the world, where animal and vegetable foods are both found in abundance and where there is opportunity for choice, show that, while vegetable foods—cereals, succulent vegetables, and fruits—compose the greater part of the bulk of the diet, animal foods—dairy products, eggs, meat, and fish—

almost invariably enter into the bill of fare. For many reasons it seems fair to conclude, with the majority of the physiologists, that this widespread habit is the result of experience and that it has its foundation in bodily needs. From the earliest times, in fact, man has used animal foods, and his whole body structure is adapted to the use of such articles of diet. Though some, for various reasons, do not favor the eating of flesh, the consensus of opinion among physiologists who have given special attention to the subject is that flesh foods are a wholesome and normal part of the diet.

Of course it is possible to overeat of these foods, but so it is to overeat of such foods as butter, or olive oil, for example; so in meat eating, as in other food habits, moderation is desirable. This is particularly the case for those who live sedentary lives involving little muscular work. Such people naturally select and seem to need less meat and other foods than those who lead out-of-door lives and do hard manual labor. The man of sedentary life, if he has the food habits of the average American family, would ordinarily take a moderate portion of meat or fish—a chop or a cutlet or a slice of roast beef—once a day, or a somewhat larger quantity divided between two or all three meals. Such a quantity would weigh from 3 to 5 ounces, an amount certainly not large. The heartier man, who leads a vigorous life in the open air, would naturally relish more meat just as he would want more bread, butter, and other foods than the man with little active work. The fact that some persons eat more meat than the circumstances of their lives demand should not be taken as an argument against meat eating in general.

According to statistics compiled in the Office of Experiment Stations, meat furnishes about 16 per cent of the total food consumed in the ordinary American family, about 30 per cent of the protein desirable in the average diet, and 60 per cent of the energy-producing fats. It is possible to obtain all of the necessary protein and energy from other materials, but for many reasons it is doubtful if such a proceeding would be either desirable or agreeable for the average person. Exactly how much meat should be eaten is a difficult matter to determine; probably if one meat dish is served a day, and other materials supplying protein, such as milk, eggs, beans, or similar foods, are also used, there is little danger of getting too much meat or too little protein. It is of course possible to eat meat dishes less frequently, or as noted above, to omit meat from the diet altogether, if one so desires and the diet is so arranged that it remains well balanced.

Meat is in general one of the most digestible of food materials. Recent experiments indicate that all kinds are thoroughly digested, less expensive cuts as well as the more costly. The higher priced cuts contain more of the so-called extractives or extractives of more pleasing quality, and it is these substances which not only give the meat its agreeable flavor, but also actually stimulate the digestive processes. They have, however, little if any nutritive value, and for persons with normal digestion the less expensive cuts, even if less rich in extractives, cooked and flavored in an appetizing way, may certainly be used to replace the more costly cuts.

Meat is undeniably one of the more expensive items in the food bill of the ordinary family, and for this reason it is important that it be bought and used to the best possible advantage. In rural communities cooperative slaughter-houses and storage houses are often useful not only in reducing the cost of meat, but in making fresh meat available in summer. If the size of her family or her storage facilities warrant, the housekeeper may find it advantageous to buy the whole carcass of a small animal, such as a pig or a lamb, or a large section of beef, thus securing better prices. Carefully following the market and taking advantage of any special opportunity that may offer also helps to reduce the expense for meat for the family in town.

It is also important to reduce waste by using as much as possible of the bone, fat, and trimmings, not usually served with the meat itself. If nothing better can be done with them, the bones and trimmings can almost always be profitably used in the soup kettle and the fat can be saved for cooking, thus saving the more expensive butter and lard. The bits of meat not served with the main dish or remaining after the first serving can be seasoned and recooked in many palatable ways, or can be combined with vegetables, pie crust, or other materials, and thus the meat flavor may be extended over a large quantity of less expensive food with such combinations. Moreover, smaller quantities of meat can often be bought than would be necessary were the meat served alone.

Different kinds and cuts of meat vary considerably in price. Sometimes the cheaper cuts contain a larger proportion of refuse than the more expensive, and the apparent cost is less than the actual cost of the edible portion. Aside from this the advantage of the more expensive cuts lies in tenderness and flavor rather than in nutritive value. Tenderness depends on the character of the muscle fibers and connective tissues of which the meat is composed. Flavor depends partly on the fat present in the tissues, but mainly on nitrogenous bodies known as extractives, which are usually more abundant or of more agreeable flavor in the more tender parts of the animal. The heat of cooking dissolves the connective tissues of tough meat and in a measure makes it more tender, but heat above the boiling point or even a little lower tends to change the texture of muscle fibers. Hence tough meats must be carefully cooked in low heat long applied in order to soften the connective tissue without unduly changing the fibers. Cooking, especially in water, presents a further danger, namely, the escape into the water of the nutritious material in the meat. In cases where the liquid in which the meat is cooked is to be used, as in soups and some stews, this is of less importance or it may even be an advantage, but where the meat only is to be used the fact must always be taken into consideration. Not only is the amount of nutritive material in the meat lessened, but the extractives are lost and with them more or less of the flavor the meat originally possessed. To lessen the chances of loss, cooks frequently sear the exterior of the meat either in hot fat or in boiling water before beginning the long cooking, or tough meat may be pounded or chopped to break down the tissues to a certain extent, and thus permit shorter cooking. Besides using such devices to retain and develop the natural flavor of the meat, other flavors may be added to supplement them. These may be put into the meat before cooking or may be added later in the form of relish or sauce.

Vegetables of distinctive flavor such as onions, carrots, or celery; savory herbs such as parsley, sage, bay leaf, or thyme; and materials such as vinegar, pickles, or currant jelly; spices such as pepper, cloves, or "curry" mixtures; and sharp or highly seasoned meat sauces are all types of flavoring materials which are useful for such purposes and which may be used in a great variety of ways.

In fact the number of "tasty" dishes which a good cook can make out of the cheaper cuts of meat or meat "left over" is almost endless. Undoubtedly more time and skill are required in their preparation than in the simple cooking of the more expensive cuts, just as more time and skill are required for careful, intelligent marketing than for haphazard ordering; but the real superiority of a good cook lies not so much in the preparation of expensive or fancy dishes as in the attractive preparation of inexpensive dishes for every day and in the skillful combination of flavors.

Some housekeepers seem to have a prejudice against economizing in such ways as those here suggested; but, if the comfort of the family does not suffer and the meals are kept as varied and appetizing as when they cost more, little ground for the feeling exists. Surely it is not beneath the dignity of any family to avoid useless expenditure, no matter how generous its income, and the intelligent housekeeper should take as much pride in setting a good table at a low price as the manufacturer does in lessening the cost of production in his factory.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 392.

IRRIGATION OF SUGAR BEETS.

BY

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1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., March 10, 1910.

Sir: I have the honor to transmit herewith a paper prepared under the supervision of Samuel Fortier, chief of irrigation investigations of this Office, by F. W. Roeding, irrigation manager in charge of the work of this Office in California, discussing in a practical way the irrigation of sugar beets. The success attained in the growing of sugar beets in Colorado, Utah, Idaho, and California, where the irrigation of beets is practiced, leads to the conclusion that large areas can be devoted to the culture of the sugar beet and that this industry will help greatly in the development of the immense tracts now being brought under irrigation. This development can be greatly promoted by the adoption of the best methods of applying water to the beet fields, and this bulletin is prepared for the purpose of supplying information as to these methods.

Mr. Roeding wishes to acknowledge assistance in collecting information on which this paper is based to the following agents of the irrigation investigations of this Office: A. P. Stover, in Oregon; John Krall, jr., in Idaho; O. W. Bryant and his assistants, in Colorado; Prof. W. W. McLaughlin and his assistants, in Utah; D. H. Bark, in Kansas; and H. I. Moore, in Montana, while the writer has covered his own field in California. The cooperation of the Great Western Sugar Company in the experiments conducted during the seasons of 1905 and 1906, and of the American Beet Sugar Company, covering the past four years, is also acknowledged, as well as the assistance and advice given by the officers of the various sugar companies throughout the territory covered.

It is recommended that this paper be printed as a Farmers' Bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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IRRIGATION OF SUGAR BEETS.

INTRODUCTION.

The discovery of a method of extracting sugar from the beet was made in 1747 by Professor Margraff, a member of the Academy of Science, Berlin, Germany, but no practical use was made of it until the beginning of the next century, when his pupil, Achard, started a factory in Silesia.[a] This was followed by the rapid establishment of factories throughout Germany and France and marks the beginning of the extensive development of the industry in Europe. In 1907 Europe's total production of beet sugar amounted to 6,575,000 tons, or nearly one-half of the world's production of beet and cane sugar for that year—14,230,372 tons.[b]

The introduction of the industry into the United States was very slow and was accompanied by many vicissitudes. Although attempts were made as early as 1830, it was not until 1879 that a successful factory was established at Alvarado, Cal., which commenced operations that year and has been in operation ever since. Although this factory and a few others established shortly afterwards were very successful and sugar manufacturing was encouraged by the payment of a bounty on all sugar manufactured in the United States from 1890 to 1894 and by a protective tariff at other times, it was not until the last few years of the past century that this important industry received the attention to which it was entitled. This was brought about largely by the discovery that sugar beets could be grown to great advantage throughout the West with the aid of irrigation.

During the year 1908 there were in operation in the United States 62 factories, with a daily capacity of nearly 50,000 tons of beets, requiring an area of about 365,000 acres and producing about 380,000 long tons of sugar. Factories were distributed among the various States as follows:

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[a] U. S. Dept. Agr., Bur. Chem. Bul. 27.

[b] U. S. Dept. Agr., Yearbook 1907, p. 686.

Number of factories and their capacities, by States, 1908.[a]

State.	Number of factories.	Capacity per 24 hours.	State.	Number of factories.	Capacity per 24 hours.
		Tons.			*Tons.*
California	8	9,100	Nebraska	1	350
Colorado	15	11,800	New York	1	600
Idaho	4	3,750	Ohio	1	400
Illinois	1	350	Oregon	1	400
Iowa	1	500	Utah	5	4,000
Kansas	1	1,200	Washington	1	500
Michigan	16	11,550	Wisconsin	4	2,300
Minnesota	1	600			
Montana	1	1,200	Total	62	48,600

[a] U. S. Dept. Agr., Rpt. 90, pp. 51–53.

In segregating these various factories into irrigated and unirrigated sections, we have—

Number of factories and their capacities in irrigated and unirrigated sections.

	Number of factories.	Capacity per 24 hours.
		Tons.
Irrigated	36	31,950
Unirrigated	26	16,650
Total	62	48,600

It appears that approximately two-thirds of the beet sugar is produced in the irrigated sections of the West, and the industry's greatest development will probably be there. The need of the development of the sugar industry in the United States is shown by the following table:

Consumption of sugar in the United States, 1909.[a]

	Tons (2,240 pounds).	
Importation from Hawaii and Porto Rico	718,788	
Importation from other sources	1,674,776	
Total		2,393,564
Domestic production, cane sugar	409,960	
Domestic production, beet sugar	434,000	
Total production of the United States		843,960
Total consumption of the United States		3,237,524

In other words, almost 75 per cent of the sugar consumed is imported.

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[a] Willett & Gray's Weekly Statistical Sugar Trade Journal, Jan. 6, 1910.

The area in which sugar cane can be grown in the United States is limited to a small portion of the country bordering on the Gulf of Mexico, and the industry is at present confined to Louisiana and Texas.

SCOPE AND PURPOSE OF THIS BULLETIN.

A practical manual, giving methods pursued throughout the irrigated beet-growing sections and thereby furnishing information to new settlers in irrigated districts, as well as suggestions to beet growers as to the practices in States other than their own, should be of value in introducing the growing of beets and improving the methods of handling this important crop. As the matter now stands, each community where this industry has found favor is proceeding along lines suggested by local conditions which are more or less peculiar, and this bulletin is designed to be a compilation of the practices throughout the West, to which are added the results of experiments conducted by this Office in irrigation of sugar beets during the past four years.

The information from which this bulletin is compiled was obtained by the various field men of this Office, by personal contact with the most successful growers in the irrigated beet-growing sections, and also with the officers of the various beet-sugar factories. The collection of these data extended through the crop season of the year 1908, while the experiments which were conducted at Rocky Ford and Loveland, Colo., date from and include 1905. The territory covered included the Pacific coast and the great interior valleys of California, the Grande Ronde Valley in Oregon, the Upper Snake, Payette, and Boise valleys, in Idaho, the South Platte and Arkansas valleys in Colorado, all the beet-growing sections of Utah, the Billings district in Montana, and the Garden City district in Kansas.

SOILS AND CLIMATE SUITED TO THE GROWING OF SUGAR BEETS.

Soils suitable for the culture of the sugar beet under irrigation comprise practically all classes, from the heavy black adobe and gumbo soils of California and Montana to the sandy loams and silts of river bottoms and mesas. The clay and clay-loam soils require much more work than lighter soils, and are more difficult to put into proper tilth. The forming of a crust after rains or after being irrigated is also a disadvantage. These soils, however, contain a much larger percentage of available plant food than the lighter soils, and under favorable conditions will produce heavier yields and are not so easily exhausted by continuous cropping. Intensive tillage, which is so important in the cultivation of this crop, has a marked tendency to render these heavy soils more friable, and it has been found that the yields increase from year to year up to a certain point. In the Pajaro Valley of California, where beets have been grown since 1888, some of the black adobe soils gave the largest returns after ten years of continuous cropping without fertilization.

The depth of the soil is one of the prime considerations in the growing of sugar beets, as the beet is deep rooted. Therefore, lands with a hardpan formation within 18 inches of the surface should be avoided, not only on account of their interference with root growth, but because of their tendency to lose moisture. Low, wet lands should be avoided also, no matter of what character, as they are usually "cold" and prevent any rapid development of the crop in the early stages of plant life, while the later growth is kept beyond the time when the beets should mature, thus causing low sugar percentages.

Alkali is to be considered also, especially as most soils throughout the West contain alkali in greater or smaller quantities. Beets will withstand the effects of alkali to a greater degree than any other summer crop, but strongly impregnated soils retard the proper development of the plant as well as lower the purity of the juice, rendering it unfit for manufacture. The white alkali or sulphate salts are far less harmful than the black or carbonate salts, but lands which show a considerable white crust in the early spring are not suitable for beet culture, while black alkali or salt lands should never be used.

Taken altogether, the best soil for this crop is a clayey loam of good depth, which contains sufficient sand or silt to allow its being worked into a finely divided condition. The underlying soil stratum should be pervious to water but not so coarse as to allow of rapid percolation. Such soils are found in nearly all the present beet-growing districts and are usually the producers of large crops of beets of good sugar percentage and high purity. As provided for in the contract between the beet growers and the sugar manufacturers, the selection of land suitable for this crop is subject to the approval of the latter's field men or superintendents. As these men are usually experienced, their judgment should be relied upon largely.

Climate naturally has an important bearing on the desirability of a district for beet culture, and in a general way it may be stated that at least four or five months of growing weather are necessary to the successful production of beets. The Bureau of Chemistry of the United States Department of Agriculture has made an exhaustive study of the subject throughout a long period of years and has published a number of bulletins giving the results of its investigations. The success which has attended this industry throughout the arid and semiarid regions may be attributed largely to the distribution of the rainfall. The absence of rain at the time of harvest is an important feature, as it permits the beets to mature. In the more humid sections of the East and Middle West rain may cause a renewal of growth after maturity, which results in a great reduction in the sugar content of the beet. The West, therefore, where moisture is applied artificially and can thus be regulated to cause maturity at a certain stage, is without doubt an ideal field for the successful fostering of this industry. From a study of the meteorological conditions of the older beet-growing sections it is found that the mean annual temperature ranges from 47° F. in Utah and Colorado to 63° F. in southern California, from an absolute maximum of 111° at Chino, Cal., to 100° in the more northern coast region, and from an absolute minimum of 28° on the southern California coast to —38° at Fort Collins, Colo.[a]

Rainfall, although not so important in irrigated sections, shows from 20 to a little less than 8 inches as the mean of the various points. With the exception of California, the portion of this that falls during the summer months, from May to September, inclusive, is 25 to 70 per cent of the total annual precipitation. May, June, and July are usually the months of greatest precipitation, which, although it can not be relied upon on account of the local character of the storms, is of considerable help to irrigated fields. In California practically no rain falls from May 15 to October 1, but the mild winters permit of early planting and a growth during the rainy season. Frost and hailstorms, if not too severe or too early, injure this crop probably less than any other, and it is therefore reasonably safe in high elevations. The fields of Colorado and Utah are all between 4,000 and 5,000 feet elevation, while fairly good crops have been produced at an altitude of 6,000 feet. All things considered, however, 5,000 feet may be considered as the maximum elevation at which success can be attained.

PREPARATION OF LAND FOR IRRIGATION.

The proper leveling of land is fully as important with this as with any other crop, and upon this feature of the work the securing of the best yield will very largely depend. It usually entails a considerable expense, but pays for itself many fold, and it would be far better for the beginner, if funds are limited, to restrict his area to a small acreage and put it in proper shape than to endeavor to handle a large area of poorly prepared land and meet with partial failure. In the latter case he will not only encounter difficulty in distributing the irrigation water evenly, thereby causing endless labor and trouble, but with unevenness in the surface it will be impossible to prevent the drowning out or scalding of his crop in the depressions. This fact can not be emphasized too strongly. In selecting the area to be devoted to this crop a fairly level field or one having a uniform slope is desirable. If the land surface is uneven and the preparation entails considerable cutting down of mounds and filling of hollows it will result in a spotted field, as all the top soil containing the organic matter will be moved off of the high places and this will expose raw soil, which will need heavy fertilizing to sustain plant growth. Furthermore, lands which have never been in cultivation should not be used for sugar beets.

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[a] Absolute maximum and minimum are the highest and lowest of which there are records.

METHODS OF IRRIGATING.

As already stated, environment and physical conditions have tended largely to determine methods of irrigation in various localities, but with the exception of California, and to some extent the Kansas and Idaho fields, the furrow method is adopted almost universally and the advantages of this method over others can not be doubted.

In California checking and bordering for sugar-beet irrigation are largely practiced and the furrow method is unknown. This may be ascribed to various causes, the principal one being that fields are largely winter irrigated; that is, water is applied before the crop is planted. The disposal of the waste waters from the factories, which were forbidden an outlet in any of the fresh-water streams of the State, due to their polluting influence, led to their use on lands near by. When the manufacturing season opened it was too late to apply this water to growing crops, so it was spread over fields which were vacant or had been harvested. In order to facilitate and cheapen the distribution of water which ran day and night the land was leveled and checked, and it was thus possible for one man to handle a large area. Large checks are avoided, the average size being from a fraction of an acre to 1½ acres. The results from this practice proved so favorable that not only is the factory waste water thus used, but in some sections all the land devoted to beet culture is winter irrigated.

Winter irrigating is also practiced in the fields of Kansas, southeastern Colorado, and Idaho, where late water can be obtained in the ditches. The winters throughout this section are generally very dry, so that when spring approaches the soil contains so little moisture that it can not be worked until the heavy spring rains occur. Evaporation is small during the cold weather, and if water is applied in the late fall the land is in shape in early spring for preparation. The advantages of this practice are obvious, for if the spring is dry it is necessary to irrigate before preparing the land, and this always presents the danger of rains following an irrigation and preventing the working of the soil until too late.

Where water is applied without previous preparation, as in southern California, slip-joint pipe is used. This pipe is usually made of light galvanized iron in lengths of 12 feet. It is moved about the field easily and does away with the evaporation or seepage loss common to earth ditches. When pipe is used, only a small area near the discharge point is covered by the aid of a shovel, then a section of the pipe is taken off and another patch wetted, and so on across the field, the pipe being laid in any direction necessary, regardless of the rows (fig. 1).[a] In this district water is scarce and its cost high, whether from pumping plants or gravity systems, so that it is necessary to exercise the greatest economy.

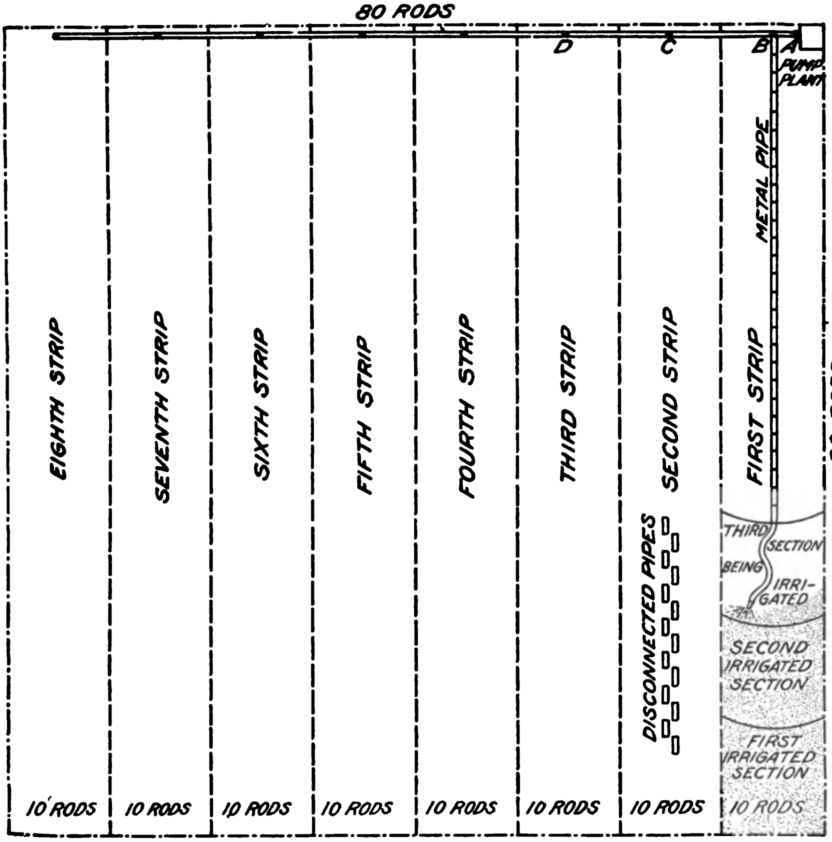

FIG. 1.—The use of slip-joint pipe in applying water to land.

In the neighborhood of Lewiston, Utah, and in southeastern Idaho a method of subirrigation is practiced, due to the peculiar soil conditions. Seepage ditches are plowed out to a depth of 1 foot or so and placed across the field at intervals of 100 to 150 feet. At the time of irrigating they are run full of water, which moves laterally from them through the soil on account of the almost impervious clay subsoil. This method is similar to the one employed in alfalfa fields in the Gallatin Valley of Montana, but its use is not to be recommended, as it tends to raise the water table and causes alkali to accumulate on the surface.

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[a] U. S. Dept. Agr., Farmers' Bul. 263.

ADAPTING METHODS TO LOCAL CONDITIONS.

The furrow method of irrigation has given without doubt the most satisfactory results, and it is possible to apply this system to fields having any configuration of surface from an almost perfect level to steep slopes, the quantity of water applied to each furrow and its depth and length being arranged accordingly. Flooding in checks or in borders, without previous leveling, as practiced in California on account of local conditions, has answered its purpose, but where irrigation is an absolute necessity during the growing period the furrow method will be found to meet the requirements far better than any other. Its first advantage is in the cost of preparing the fields and the ease with which they can be kept in condition; second, the ease with which the water applied can be kept from touching the plants and thus forming a crust of earth around them. This is acknowledged by all experts on this subject to be a decided advantage. The ideal condition is brought about by the maintenance of a continuous good mulch close to the beet itself so as to prevent evaporation from the soil surface, and by cultivation after irrigation to break up the wetted area in the furrow into a finely divided condition. Furthermore, the furrow system leaves the surface in shape for any other crop which may be used in rotation.

Checks and borders in the field interfere more or less with the planting, working, and harvesting of the beets, prevent the danger of drowning out beets by careless application of water, and make considerable waste ground in the field. Levees are seeded like the rest of the field, but, being above the surface of the checks, they do not receive much moisture and usually the beets are small.

FURROW IRRIGATION.

Preparation for irrigation in furrows entails giving the surface a uniform slope throughout, so that water may run through the furrows without interruption. On lands which are fairly level a leveler or float is the commonest implement used. This is generally homemade and is fully described in a previous bulletin of this series.[a]

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[a] U. S. Dept. Agr., Farmers' Bul. 263.

The land should first be plowed in lands to a depth of 8 or 10 inches; plowing around a field should always be avoided, and all dead furrows should be eliminated as far as possible by back furrowing into them several times. The lands should therefore be of considerable width, even if time is lost at the turns. In this connection it may be well to speak of a type of plow which is coming largely into favor in many of the beet-growing sections and which does away entirely with both back and dead furrows, since all furrows are thrown in the same direction. This plow is a sulky and is made in two types, called "reversible" (fig. 2) and "balance" (fig. 3). The reversible consists of right-hand and left-hand plows set opposite each other on a beam. When the end of the field is reached the

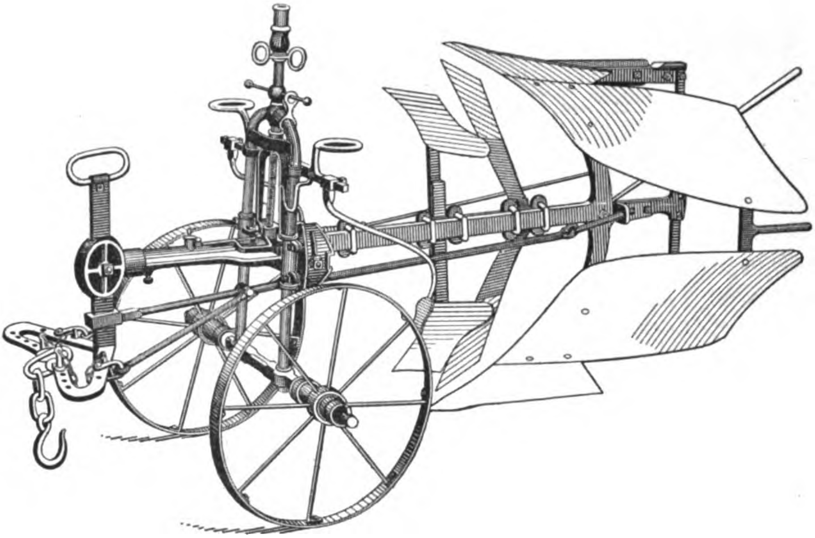

FIG. 2.—Reversible plow.

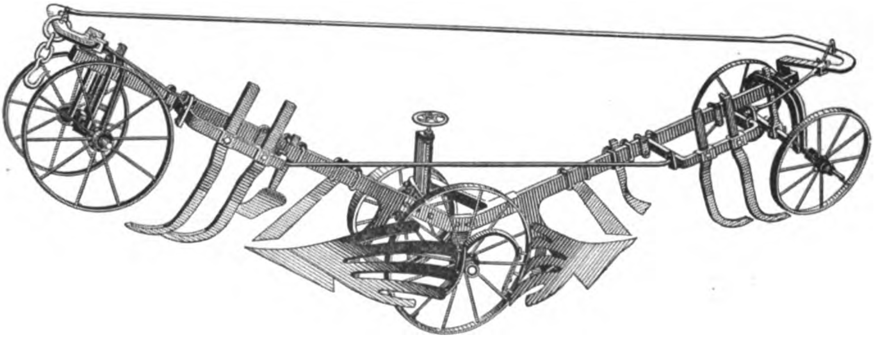

FIG. 3.—Balance plow.

plow is thrown out of the ground and reversed by means of handles at the back, and when the implement is turned around the other plow throws the furrows in the same direction as the previous furrow. Another type, accomplishing the same purpose, consists of a sulky frame carrying right and left plows, with levers for raising and lowering the plows so that either one can be held out of the ground while the other is in use. The balance plow consists of one or several plows in gangs, fastened to two frames, which are set at an angle of 135 degrees to one another, the axle and wheels being at the angle (fig. 3). One frame contains right-hand and the other left-hand plows. The drawbars at the ends are joined by means of a heavy round steel rod (fig. 3), and a loose ring connects the team to the drawbar, so that when the end of the field is reached the team is swung around on the unplowed ground and the ring travels from one drawbar to the other by way of the rod, and as the plow starts up it pulls one plow out and the other into the ground, thus obviating the necessity of throwing the plow out as in the reversible. On larger areas engines are used. These have become quite popular also with sugar companies farming their own lands. The outfit consists of two traction engines and the balance type of plow. The engines are fitted with drums by which the steel cables attached to the plow are pulled backward and forward between them. This method permits of very deep plowing, up to 24 inches, as no energy is wasted in traction and the entire power is exerted on the plow. As soon as one engine has drawn the plow to its side of the field it moves up to a point opposite the new furrow which the plow will make when pulled back. The advantage of this type of plow, not only in preparing land for irrigation but in keeping the surface in a uniform condition after preparation, can not be overestimated.

A disk harrow should follow the plow as soon as the plowed soil has dried sufficiently to pulverize without clogging the spaces between the disks. The harrow should lap half its width on the previously disked ground, thus going over the field twice at one time and filling the furrow left between the two disk sections. Harrowing across the disking will place the surface in a fairly well-pulverized condition. After the prepared ground has laid several days, to permit settling and drying, it is ready for the leveler (fig. 4). This should run first across the harrowing, then with it, and finally diagonally across both ways. In running across the field so often the operator will be able to detect unevenness and to use the cutting blades with considerable skill and can then decide whether it is necessary to go over the field again. He should, however, always keep in mind the advantages of well-leveled ground and spend rather too much time in its preparation than too little. With a float (fig. 5), which is not provided with a cutting blade, the fills or cuts are made by the driver shifting the weight of his body along its length. The only advantages in a float are that it requires the services of the driver only and its construction is cheaper, while two men are required to run the leveler. Otherwise the operation of the leveler is more satisfactory. The main advantage in either implement is in its length, and this should be not less than 18 feet.

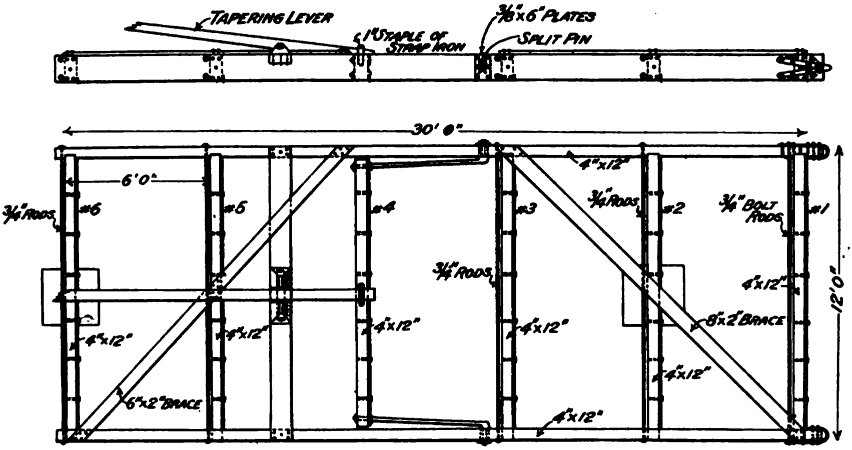

FIG. 4.—Rectangular leveler.

Where land is more uneven the use of the buck or dump scraper is required to cut off high ground and fill up the low places. This should be followed by the leveler or float after plowing and harrowing as described above. If after the scraper work is completed there are not sufficient rains to settle the soil which has been dumped in the depressions, it is well to irrigate the land in order to settle it thoroughly. If this is not done it will be found that the fills will

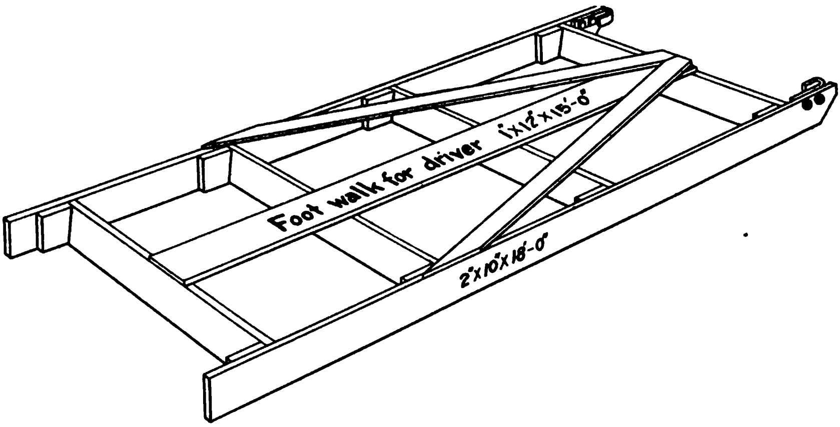

FIG. 5.—Float for leveling land.

settle later below grade and cause an uneven field even though the land appears level on completion of the work.

Taking for granted that a drill with furrowing attachment has been used in seeding, thus marking the rows, the first step is to furrow out either with furrowing shovels attached to a cultivator, using the shield on either side to prevent the furrowed earth from being thrown above the seed, or with the furrowing sled, so much used in the Arkansas Valley.

The furrowing sled.—This sled is constructed in various ways, but figure 6 shows one which gives the best results. It is made of 6 by 6 inch timbers 42 inches long as runners, and spaced wide enough to straddle two rows. These timbers are set to run on edge and are sharpened at the forward point and armed with old furrowing shovels, which about fit them. The runners are securely spiked together at the back end with 2-inch boards upon which the driver rides, and are connected in front by a 4 by 4 inch timber, to which the draft is attached. Either one or two horses are used, two being preferable, as there is not so much danger of the sled shifting from its line. This implement makes a smooth, even furrow, without clods to interrupt the flow. With it furrows can be placed in alternate rows or every row, as desired. In the latter case a furrowed row would be straddled. More runners could be placed on the sled to furrow out more than two rows at a time, except that slight unevennesses in the surface will prevent the making of as good furrows. Smooth furrows, especially for irrigating up the seed, are most essential and no other tool can be secured to give as good results as this homemade device. More crude forms are made of two straight limbs of cottonwood, 5 or 6 inches in diameter, for runners.

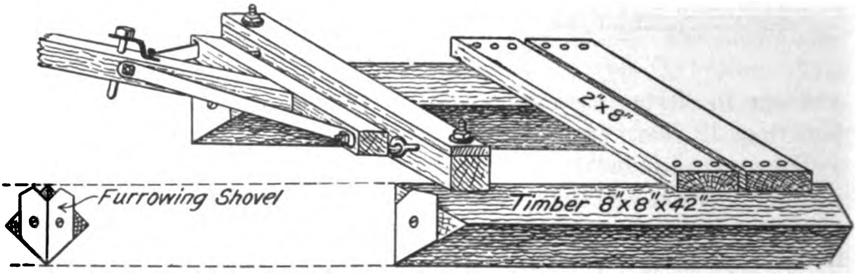

FIG. 6.—Furrowing sled.

The two-row or four-row beet cultivator with long-winged furrowing shovels attached is probably more largely used in making furrows than any other implement. Ten acres per day can be covered with the four-row cultivator, and 5 acres with the two-row implement with one or two horses and one man, while preparing the field with the furrowing sled after cultivation requires about two or three times as much work. The advantage of the sled is in the lesser cost of the implement, which would be a decided advantage on small fields and the better work in making furrows and distributing water.

If at the time of irrigation the soil under the mulch has become dry and hard, a cultivation with deer or bull tongues in the center between rows to loosen the packed soil will be found helpful, as it permits the making of good, deep furrows, and overcomes the resistance which a dry, packed soil has to water. When furrowed out with the sled, as described already, a deep, smooth runway for the water is obtained. When the furrows are made with the furrowing shovel a deer tongue or soil-loosening tool can be placed in front of the furrowing shovels and the whole operation completed at once. After the rows have been furrowed out, as described, it is necessary to prepare head ditches from which water can be turned into the furrows. This is accomplished by plowing out a ditch parallel to the field lateral which serves the area. The head ditch is then cut into sections with earth dams, each section serving a certain number of rows, according to the grade of the ditch, and connected by a gate to the lateral ditch. The bank next to the furrows is cut for either one or two furrows and the water turned on. By having head ditches the water can be well distributed and several sections can be running at the same time if there is sufficient water. The amount allotted to each furrow should be small, so that it will run slowly and secure a good saturation, as well as prevent wetting the soil over the seed. At intervals of 300 to 500 feet there should be cross ditches which will intercept waste water from the rows above them and also supply water to the lengths of rows below. It is a grave mistake to attempt to run water the entire length of a field if this is more than 500 feet, as the upper end will become too wet before the water reaches the lower end. The slope naturally determines the distance between cross ditches, and where this is considerable they can be spaced at greater intervals, but on flatter areas 300 feet or even less will be found sufficient. Cross ditches are made by simply plowing out dead furrows with a good-sized plow, either single or double moldboard. If parallel head ditches are placed along each cross ditch it will result in the destruction of too many beets, so that here the water is run to the lowest point on the cross ditch and turned into a section of rows. When these are irrigated a dam is thrown in and the water diverted to the next section. By having a waste ditch around the lower end of the field the water can be regulated to the required quantity.

Lath boxes or tubes in ditch banks.—The amount of water distributed to the furrows can be controlled better by the use of small lath boxes or sections of tin or iron pipe placed in the lower banks of the ditches. The former have been in use at Rocky Ford, Colo., and in southwestern Idaho for some time, but their use has been very limited, due to the extra labor entailed in placing and removing them, but the saving in labor due to the better regulation of the water applied to each furrow does not seem to have been considered. When made of lath, as shown in figure 7, they leave an opening about 1 inch square. Their length should be at least 2 feet, while 30 inches is better, so that they will protrude a little each side of the bank. If well placed they will give a very uniform flow into the furrows, but if one runs more than another the simple device of partially closing the opening with a few blades of grass will give the desired results. The boxes are also made so that two opposite sides project beyond the others a couple of inches, as illustrated. The advantage in this is that the opening can not be entirely closed by the lodgment of floating material against it, and also, when desired, the flow can be stopped better by wedging material between the projecting sides.

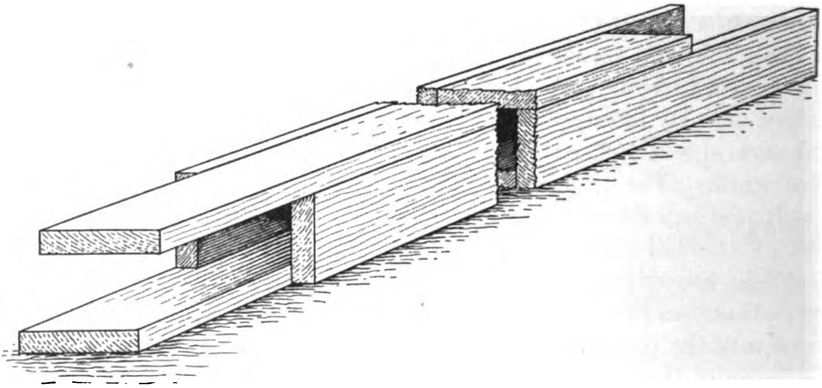

FIG. 7.—Lath box for distributing water to furrows from head ditch.

Old water pipe of 1 to 1¼ inches in diameter, cut in lengths of 2.5 feet, or, better still, round, well-soldered tin tubes of the same length and diameter, will be found cheap and efficient. Figure 8 shows the arrangement of the field just described.

The method of irrigation practiced in Payette and Boise valleys, in Idaho, is worthy of particular mention. Lath boxes for either one or two furrows are placed in the banks of the field laterals. The banks are constructed higher than would be absolutely necessary and the boxes placed somewhat higher than the level of the land. Check gates are placed in the ditch at intervals, so that the water may be held at a uniform height above the boxes, giving an equal head over all boxes and producing a uniform flow. The flashboards in the gates are lower than the crest of the banks, so that should a larger stream than is necessary for one section of the ditch be turned down it will waste over the top of the gate into the next section of the ditch. In this way a good many furrows can be receiving water at the same time, and one irrigator is sufficient to watch them. Where night irrigation is practiced the ease of distributing the water after it is once regulated, and therefore the small amount of labor entailed, is a decided advantage. When the furrows from one section of the ditch are all sufficiently wet the removal of the flashboard lowers the water so that no more will run through the boxes in that section. The only criticism which can be made of this system is the danger of the lath boxes washing out. Where either iron or tin pipes are used this danger is obviated very largely, as there are no joints from which leaks can occur to cause a break. Furthermore, by having a tin flange 6 or 8 inches square soldered on at the middle point of the tin pipe, which would prevent water running along the outside, breaks could be done away with entirely. The expense in arranging such a system is considerable, but this is fully repaid in the saving of labor and water and in the uniformity of the irrigation.

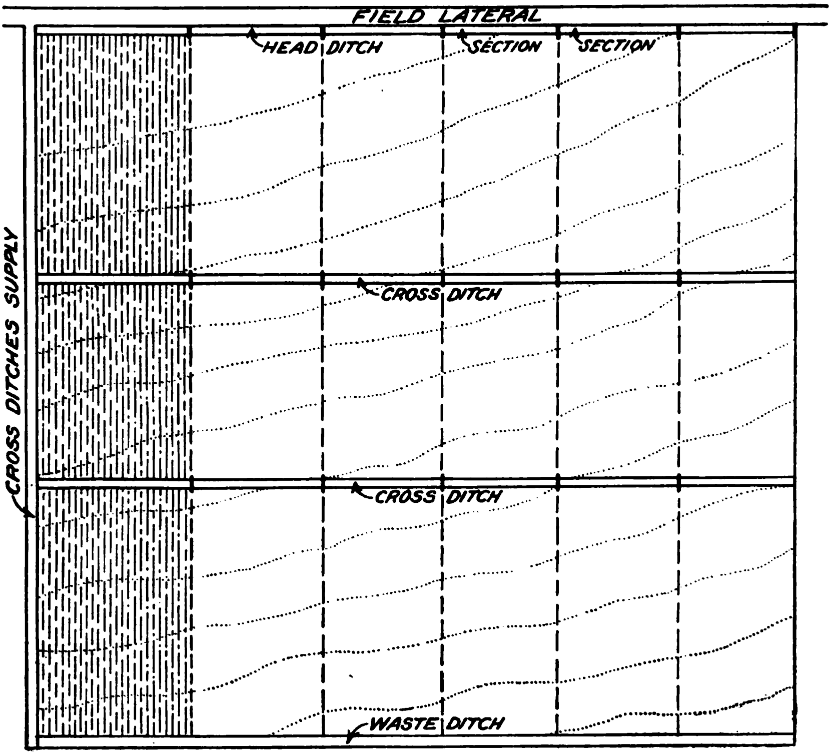

FIG. 8.—Plan of field-furrow irrigation.

Where furrow irrigation is practiced without boxes, head ditches are placed along field laterals of considerable size and the cut-outs are made in their banks for one to four rows each. Wooden gates are placed in the lateral ditches to hold up and divide the stream, and outlet boxes connect the head ditches to the laterals. This is the best practice, as it permits of regulation without continual watching. If a lateral is small, the cuts are made in its bank. Where the soil is heavy there will be little or no wash, but in lighter soils the cuts will have to be watched closely or the entire bank may be washed away. The use of this method permits of the handling of large quantities of water and rushing it over the field quickly, but it is little better than a flooding, as it is next to impossible to distribute the water to a large enough number of furrows and keep it divided evenly so that it will not run over onto the beets. Where the fall in the ditch prevents an even distribution of the water to the various cut-outs, the simple device of placing a few sticks in the bottom and throwing in some weeds on the upstream side will check the flow and cause a slight rise above the obstruction.

THE CHECK METHOD.

The check methods followed in California for preparing beet fields are the same as those employed so largely in preparing land for alfalfa,[a] except that in some sections, like the Santa Maria Valley, the border checks are temporary, being leveled down when the land is prepared for planting. Gates for the checks or borders are also avoided, as they would interfere materially in the planting and harvesting of the fields.

In the check system a field is divided into rectangular basins or checks by levees, and lateral ditches are run between the lines of checks so that water can be distributed to both sides of a ditch. The checks nearest the head of the ditch are filled first by throwing a temporary earth dam or a canvas dam across the stream and cutting the banks. Each set of checks is filled in turn until the lowest is reached. In this way, should breaks occur, the water will cover the lower lands without waste, and finally, when all checks on that lateral are filled, there are no cross dams to be removed. The same process is employed with both temporary and permanent borders.

THE BORDER METHOD.

Even when the land is irrigated in border checks, furrows can be placed and better results obtained than if the water is flooded over the land without runways, but beets which are planted on the crests of the levees will not develop like those within the checks, and the tonnage per acre will be smaller.

In the Garden City, Kans., district, the border method is practiced, both with and without furrows. The borders are temporary and are 50 to 80 feet apart, the length varying from 300 to 1,000 feet, according to the slope and character of the soil. The rectangular or contour checks must be flooded, but where the soil is heavy and the downward movement slow some provision should be made to remove the excess water so that it will not stand for any length of time. This is done usually by cutting through a levee and drawing it off into a lower check. The practice followed sometimes in alfalfa fields of running water from one check to the others below without feed ditches would result disastrously if applied to this crop, as it would mean that the higher checks would be continually under water until the lowest is covered, and thus would a great part of the crop be drowned out or scalded.

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[a] U. S. Dept. Agr., Farmers' Bul. 373.

The temporary borders are used only before planting, and consist of levees extending parallel to the slope of the land at intervals of about 10 feet. These checks are thrown up usually by back furrowing with a 14-inch or 16-inch plow. In irrigating the water is distributed evenly by the use of shovels, and as this work is done on the unplanted ground it is not necessary to have the land carefully leveled.

In other sections of the California and Kansas fields practically no leveling is done, the water being simply flooded over the land, between temporary borders running down the slope. A more detailed description will be found above. The cost of the various methods of preparation depends largely on the unevenness of the surface, but in general it may be stated as follows:

Cost of preparing land for irrigation.

	Per acre.
Furrow irrigation	$5–$15
Rectangular or contour checks	15– 35
Border checks	12– 25
Temporary borders	1– 4

Permanent field laterals are placed on the highest ground and arranged to give the most economical service. If it is possible to do so they should be placed along the borders or so distributed over the field that they will not interfere with the working of the land in large bodies. Their size is dependent upon the area to be covered, but care should be taken to have the bottom as near the level of adjacent land as possible, so that there will not be any large quantity of slack water in the ditches. This can be done best by throwing dirt from adjacent land onto the line of the ditch by means of a scraper, and then plowing out the center of this ridge and finishing with a "V" or "A." A slope of 0.05 to 0.02 foot in 100 feet is sufficient for laterals, but if necessary greater grades may be given, depending upon the size and location of the ditches and the character of the soil. In the lighter soils the velocity of the water should not exceed 0.5 to 1 foot per second, otherwise there will be erosion and a consequent deepening of the ditches, so that the water can not be taken out at points desired, but in heavy soils greater grades may be given if necessary, as the danger of washing is less. The spirit level mounted on a tripod, or various other cheap contrivances, can be used for locating, and this is far safer than simply running by eye.

Where ditches are small and construction inexpensive, many farmers prefer to plow them out each year, as it does away with weeds along their banks. The cost of keeping a ditch clean will not be much less than that of making a new ditch, and if ditches are destroyed the plowing of a field as a whole can be done without interference.

SUBIRRIGATION.

In southeastern Idaho and northern Utah, where the seepage ditches are used, wells of riveted galvanized casing or wooden boxing are sunk to a depth of 5 to 10 feet so that the height of the water table may be observed. As stated before, this method can be employed only where the subsoil is sufficiently impervious to permit of a strong lateral movement. A warning not to attempt to make use of this system where alkali is present is extended, as it will bring the salts to the surface and render the land useless. This method requires very little attention, as the ditches are filled and regulated so as to hold the water at a certain height until the water table has risen to the desired height, where it is maintained throughout the growing season by regulating the supply in the ditches. This means a considerable loss through evaporation and is not as economical as surface irrigation, but it is practiced with good results in the districts mentioned.

Where no permanent structures are installed in the ditches to check the water the canvas dam is generally used (fig. 9). This dam is cheap, effective, and easily moved from place to place. The width and length should be sufficient to give plenty of bearing surface on the sides and bottom of the ditch. A little soil shoveled along its edge where the water covers it will make it practically water-tight. The best method of making these dams is to sew one edge over to form an opening for either a 2 by 4 inch or a 4 by 4 inch stick, as may be desired, according to the width of the ditch. If for a 2 by 4, 8 inches of one side would lap over and be sewed throughout its length, thus permitting the stick to be thrust through without trouble. When its use is no longer desired the stick can be withdrawn and the canvas folded up and put away for future use. This arrangement will preserve the cloth and also give a stronger hold than if tacked to the stick.

Tappoons made of sheet steel in various ways are used to some extent, but these are not as satisfactory as the canvas dam, particularly in a dense soil, as it is difficult to force them into the bottom or sides of a ditch to prevent the water from cutting under or around them. If earth dams are used the soil should be taken from the ditches below the dam, so that when it is cut the earth will be washed back and fill up the hole.

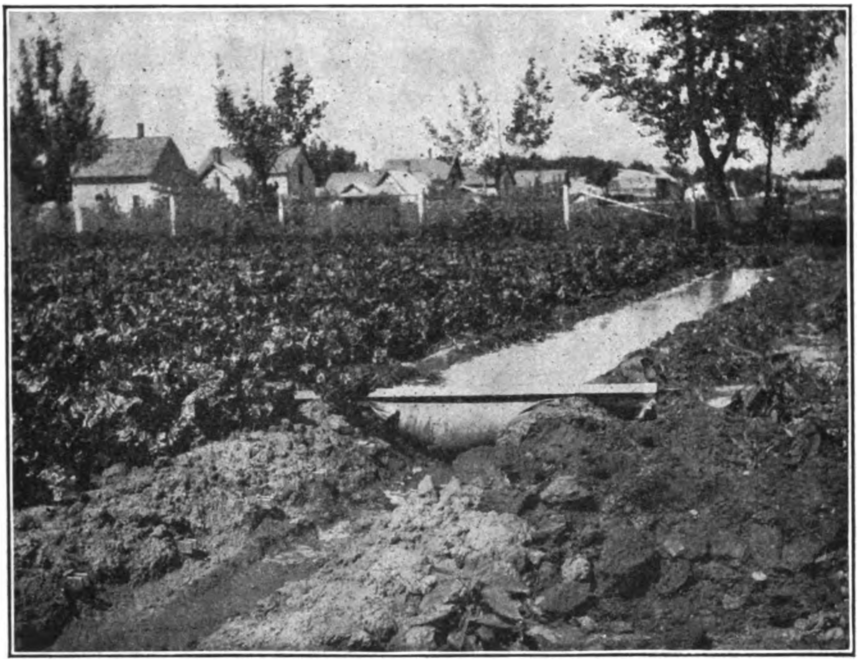

Fig. 9.—Canvas dam in lateral.

TIME OF IRRIGATING.

As already stated, it is essential that there be sufficient moisture in the soil at the time of seeding to bring the plants up, and it is better to irrigate before rather than after seeding. The next irrigation, or the first in case it is not necessary to irrigate to bring the beets up, should be delayed as long as there is sufficient moisture in the soil to keep up a steady growth. Too early irrigation tends to make a turnip-shaped beet and produces an unusually heavy growth of leaves without a corresponding development of the root. Figure 10 shows four beets from the experiment grounds at Loveland, Colo., which fully illustrate the advantages of holding off the water and forcing the plant to seek it with its taproot. The experimental field from which these plants were taken at harvest time was planted on

April 8, 1905. Plant No. 1 did not receive irrigation water until August 9; plant No. 2, on July 26; plants Nos. 3 and 4, on July 17. The number of irrigations during the season corresponds to the numbers shown on the photograph, that is, No. 1 was irrigated once, No. 2, twice, and so on. The year was an unusually favorable one, as rains were bountiful and well distributed, so that little irrigation was necessary. The soil was kept in a thorough state of tillage by frequent cultivations, and the loss of moisture by direct evaporation was slight. There is a middle course as to the time of this application of water to the crop, for if held off too long the beet will begin to mature and so prevent its proper development later. Experience alone will decide the best practice, but in a general way it is no advantage to this crop to irrigate it when there is sufficient moisture in the soil to keep up a vigorous growth.

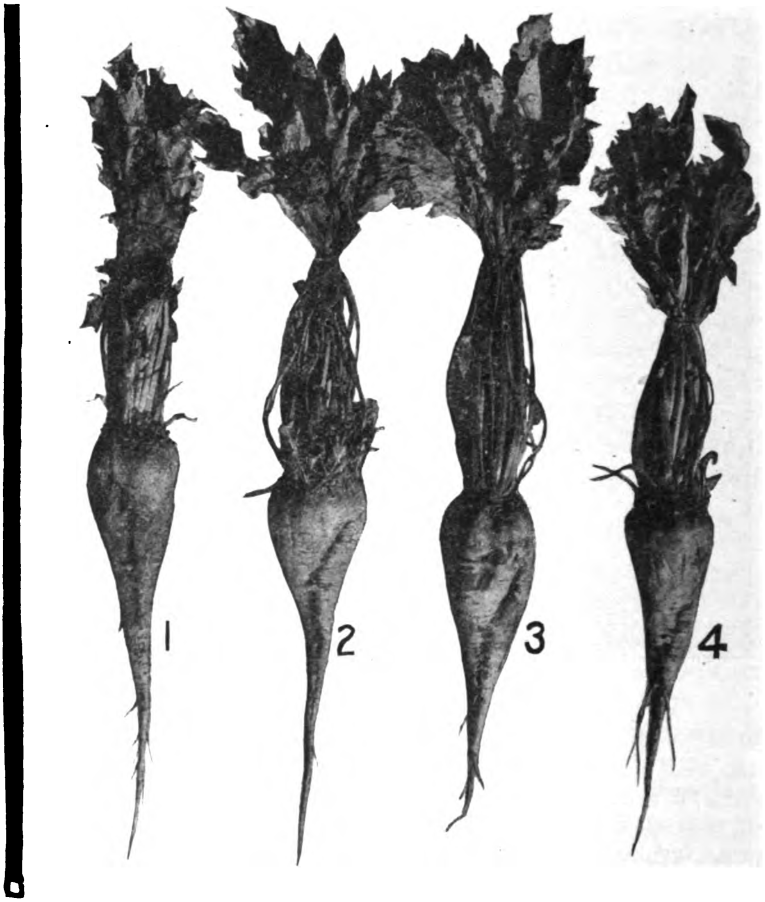

FIG. 10.—Beets, showing effects of early and late irrigation: No. 1, irrigated August 9; No. 2, irrigated July 26; Nos. 3 and 4, irrigated July 17.

After irrigation and as soon as the soil has dried out sufficiently, a cultivation 3 or 4 inches deep should follow. The narrow cultivator shovel, bull, calf, or deer tongues should be used in order to pulverize the soil as much as possible. If the beets have become so large that the leaves would be injured, the use of these implements would injure rather than benefit the crop and should be avoided. The furrows will then remain as they are in furrow irrigation and serve for subsequent irrigations. If plants are not too large, the furrowing for following irrigations should not be put off too long after the cultivation, as there would be danger of injuring the leaves.

The time for subsequent irrigation will depend largely upon the weather. The beet leaves being of considerable size and the weather warm the evaporation from their surface is great and on hot days they will wilt, but this is no sign that another irrigation is required, for on examination it will be found usually that the soil contains considerable moisture, the beets wilting because the root is not able to supply moisture to the leaves fast enough to make up for the evaporation from their surfaces. As soon as night falls and evaporation is greatly curtailed the leaves will assume their normal condition. As long as the leaves look fresh and healthy in the early morning it is unnecessary to give them water, but should they show signs of wilt at that time another irrigation is necessary.

Two to four applications of water should be sufficient, except on very porous soil, where the moisture quickly drops below the point where the roots can reach it. Under such conditions more frequent irrigations are necessary.

In many of the irrigated districts there is a question as to the relative advantages of irrigating in the daytime or at night. In some sections where the supply is limited it is necessary to use water for the entire period in which it can be obtained, so that day and night irrigation is practiced. Again, many growers object to night work, as it deprives them of sleep and it is more difficult to control the water properly. Those who advocate night irrigation, however, have found that they obtain better results, especially where the temperature of the water is low. Their contentions are that the water will go farther, due to less evaporation; that the water is warmer at that time, on account of its exposure to the sun during the day; and finally, that there is far less danger of scalding or drowning out than during the hot period of the day. All of these contentions are well borne out by the facts. It may be stated also that the proper leveling of the field and the use of boxes or tubes for distributing the water to the furrows, as practiced in the Payette and Boise valleys of Idaho, would render night irrigation no more difficult than day irrigation, while results would be generally better.

The final watering, as a rule, should be four to six weeks before harvest, so that there will be ample time for the plant to mature and store its sugar. In this connection it may be well to call attention to the fact that if the beets mature during the warm weather, some time before they are harvested, the percentage of sugar will decrease gradually. Experience alone will decide the best practice to have the crop ready for the factory when it is at the proper stage of ripeness. The decision as to this latter question is entirely with the field men employed by the factory. At this stage they may visit the various fields in their districts and select beets, usually 5 or 6, at various points in the field. These are turned over to the factory chemist for analysis, and if the sugar percentage and purity are sufficiently high orders are issued to harvest the crop.

BEET CULTURE UNDER IRRIGATION.

PLOWING.

All sections are agreed upon the necessity of deep fall plowing. A depth of 8 to 10 inches should be the minimum and subsoiling from 4 to 6 inches below that will be found advantageous. Here, also, plowing around the field should be avoided. Where land is arranged for the furrow method of irrigation and the ordinary plow used, the direction should be only with the slope; plowing at right angles to the slope will leave the dead and back furrows in the field in such a position that even if smoothed over by cultivation they will prevent a uniform flow of water through the furrows. This plowing should be left without cultivation so that the soil may be well aerated and be able to catch and retain snow or rain without drifting or run-off. On land which is checked the direction of the plowing is not essential except as it affects permanent ditches, but either dead or back furrows would interfere with the even surface of the basins, and the former would cause cuts in the levees. Where fields have been winter irrigated in California they must be thoroughly cultivated after watering, so as to retain the moisture applied. Disking and harrowing the soil, as described for the leveling process, will be found to be the best means in most fields.

Excluding California, the plowed fields remain generally in their rough condition until spring, except as frost and moisture smooth them somewhat. In early spring a double disking, allowing the disk harrow to lap one-half on each round, would smooth up the surface. If the winter has been very dry and there is not sufficient moisture to sprout the seed, the land should be irrigated after disking. It is wise to do this as early as possible, for if delayed too long rains might closely follow the irrigation, making the soil so soggy that it would be impossible to work it until too late for planting. This irrigation (furrow method) would consist of running furrows with either the two-row or four-row cultivator, with furrowing shovels attached, set 18 or 20 inches apart, as would be necessary for the beet crop, but larger quantities of water could be used and cross ditches would be needed only at intervals of 600 or 800 feet.

Whether the land is irrigated or not it should be plowed again in the spring, but not deeper than 4 to 6 inches, and then so prepared that the top soil will be well pulverized to a depth of 2 to 3 inches with a firm, moist bed below. It is well to remember that the beet is a very tender plant in the first stage of its growth and the slightest obstruction before appearing above ground will interfere and retard it; therefore the surface soil should be worked into as fine a mulch as possible.

When the field has been worked into as perfect a seed bed as possible it is ready for seeding. Many implements are used for pulverizing, depending upon the character of the soil—round, cutaway, and spading disk harrows, rollers of various types, spring-tooth and other harrows, cultivators, and clod mashers being among the most common types. The lighter soils are not difficult to prepare, and the more common farm tools can be used; but the heavier soils, which must be worked at a certain stage of dryness in order to prevent their becoming cloddy, are very often a problem to their owners. Should clods form, due to the inability of the farmer to work all his land at the proper stage, clod crushers or various types of rollers are necessary, but where rollers are used they should be followed by a harrow in order to loosen the surface soil. Ring or corrugated rollers will be found most efficient where hard clods are to be dealt with. Being heavy, their work is far more effective with uneven sets of disks or surfaces than that of rollers of the same weight having a smooth surface.

SEEDING.

The ordinary four-row force-feed beet drills made by various manufacturers are used for seeding. These drills are all of the shoe type, as a disk is not necessary where the soil is properly prepared. The seed is planted to a depth of 1 to 2 inches, depending upon the character and dryness of the soil. In the heavier soils, unless dry, shallow planting is necessary, so that the beet may appear above the ground as soon as possible before a rain crusts the surface. But in sandy soils, where there is no danger of baking, deeper planting is practiced. Press wheels follow behind the shoes, arranged so that the soil is firmed either side of the seed, but left loose directly over it. In many districts furrowing shovels are attached, which make small furrows between the rows. This is a decided advantage, and the practice should be universal throughout irrigated districts, as it shows just where the rows are in case it should be necessary to irrigate or to break the crust formed by a rain before the beets have sprouted. Where the fields are of considerable area the sowing should not be continuous, as it will mean the employment of a large number of thinners to get the beets properly spaced before they become too large. A drill should sow 10 acres a day, and it is best to allow several days to elapse between sowings, so that the beets may be thinned at the proper stage of growth. When this is done it is well to harrow just ahead of the seeding each time, the harrow running at right angles to the rows. The distance between the rows varies considerably in different localities. In California plantings are made as narrow as 14 inches, while where summer irrigation is a necessity 18 and 20 inches is the rule. The greater width permits working the beets with horse implements without much danger of trampling the plants, and is therefore best. In some sections of northern Colorado it is common to alternate 16-inch and 24-inch rows, or 18-inch and 22-inch rows, the wider ones being used as paths for horse implements or for furrows in irrigating. The best spacing of rows is such as will permit the continuous cultivation of the beet, which is so essential to success, and also the furrowing of each row for irrigation. Rows should be run with the greatest slope of the field, except of course in the check system, where this would not apply and the rows are placed so that the drill has to make the least number of turns. The straightness of the row is also a consideration on irrigated areas and the factories very often drill in the seed for growers, providing the drill, man, and team at so much per acre. The teamster is usually a man of experience with a good, steady team, so that fields seeded in this manner show almost perfect alignment in the rows.

The quantity of seed sown varies with the locality, and runs from 8 to 25 pounds per acre. Light seeding is practiced in sandy soils along the California coast, where there is little danger of a crust or insect pests injuring the young plants, but in the clayey soils the use of 15 to 25 pounds is recommended, so as to be assured of a good stand. If it were possible to so distribute seed in the rows that the plants would come up properly spaced, considerably less than 1 pound per acre would be required. Although numerous drills which are claimed to do away to a large extent with the cost of thinning and excess seed have been tried, none of them has been successful, and the heavy sowing to secure a large number of plants evenly distributed throughout the row is found most satisfactory.

The time of seeding is important and naturally varies with the locality, particularly in California, where it extends from the end of October to May. In Oregon seed may be planted as early as the beginning of March, while in the colder climates the latter part of April to early May is the best time. As early seeding as the conditions permit is always recommended, as this gives the beets a chance to develop considerably before the hot weather comes on and to mature before it becomes too cold. Should the young plants be damaged or partially destroyed for any reason, there is also the opportunity of reseeding and still obtaining a good stand before the season is too far advanced. Therefore, outside of California, the rule is to get the seed in the ground as soon as spring has fairly opened, while in the latter State plantings are so distributed that the crop may be ripening during the entire period of the factory run.

It is essential that there be sufficient moisture in the soil to sprout the seed. If there is not, it is far better to irrigate before planting, as already described, if not too late, than after seeding. Should unusual climatic conditions so dry out the soil after planting that the seed is not sprouting uniformly, and there is little prospect of rain, it becomes necessary to apply water artificially. This is one of the most critical conditions which the beet grower has to face, and good results are the exception rather than the rule. In such a contingency the proper leveling of the ground will show its marked advantage, as under these conditions, more than at any other time during the growing of this crop, it is necessary to confine the water to the furrows and prevent it from covering the soil over the seed. If this can be done, a good stand is assured. If the soil over the rows has been wet and a crust has formed after a rain or irrigation before the beets have sprouted sufficiently, it is very important that it be broken, as the plant at this stage is so slender and weak that the slightest obstruction will stop its growth. Various methods for breaking such crusts are practiced. The most common is to use the peg-tooth section harrow with the teeth set well back, at an angle of about 60° from the perpendicular, and harrow the field crosswise of the rows. This destroys some of the beets, especially where the plants are caked in the crust, but if sufficient seed has been planted there may be a good stand left. A roller, either corrugated or plain, is run crosswise of the rows to break a crust, but it has the effect of packing the soil. Seemingly, the best method is the use of "spiders" (fig. 11) on a beet cultivator, though this method occupies more time. Two spiders are attached for each row and run on either side. The sharp points of the implement, if not run too deeply, prick into and break up the crust without otherwise disturbing the top soil, and their use should be more general.

BLOCKING AND THINNING.

When the beet has four leaves it is ready for blocking and thinning. The packing of earth around the beet after thinning is desirable, as it is weakened by the removal of its neighboring plants, and this practice is strongly recommended by sugar companies.

The blocking consists in chopping out plants with a hoe, leaving them 1 foot to 8 inches apart. This was done with one stroke, and the remaining bunched plants are then thinned down to one by removing all the others by hand. The strongest plant should always be selected, but this is a difficult matter to regulate where the work is done by contract. Thinning to 8 or 10 inches should be sufficient, as this controls the size of the beet to a considerable extent. Beets weighing from 1 to 3 pounds are most desirable, as they contain higher sugar percentages and purity than larger beets, which accounts for the condition imposed in most contracts that beets weighing over 5 pounds each will not be received at the factory. As the beets come up thickly there is danger in thinning them of leaving two

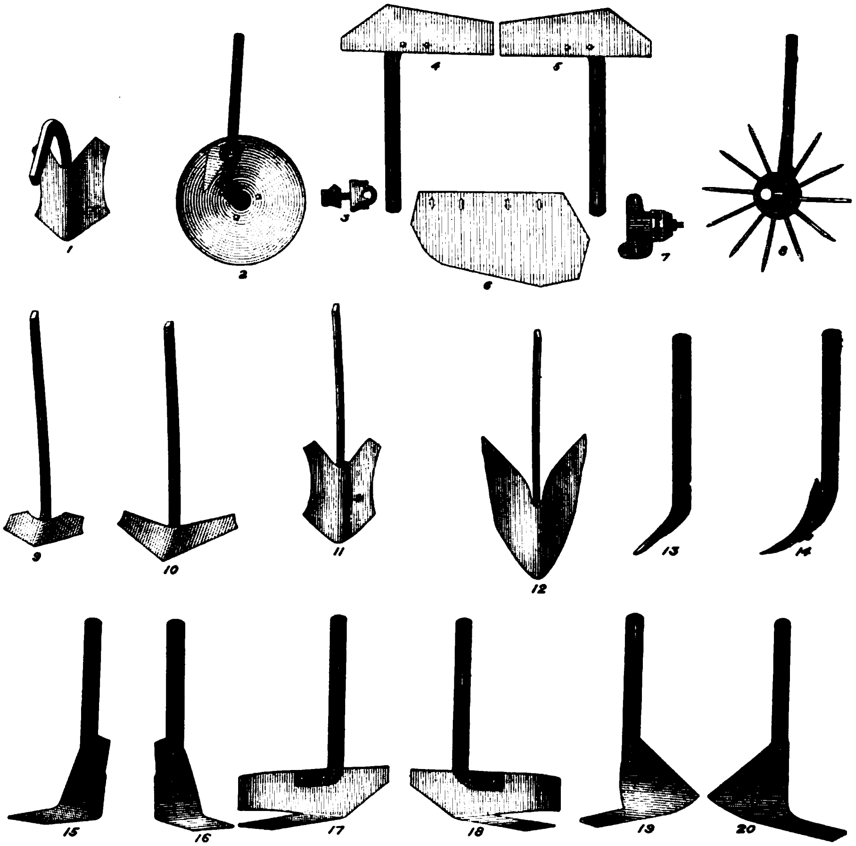

FIG. 11.—Weeding, cultivating, and furrowing attachments for beet cultivator: 1.—Seeder irrigating shovel. 2.—Disk weeder. 3.—Spider and disk clamp. 4 and 5.—Cultivator shields. 6.—Seeder shield. 7.—Reversible clamp. 8.—Spider. 9.—Duck foot No. 1. 10.—Duck foot No. 3. 11.—Irrigating shovel No. 1. 12.—Irrigating shovel No. 2. 13.—Deer tongue. 14.—Diamond point shovel No. 2. 15 and 16.—Weeding knife No. 1. 17 and 18.—Weeding knife No. 3. 19 and 20.—Weeding knife No. 5.

plants very close together. As this work is done in a hurry some of the small plants are often overlooked, and it is usually stipulated in contracts for this work that one of the double plants shall be removed at the time of the second hoeing. By that time the beets have attained sufficient size to be noticed readily and the removal of the extra plant is important, for if two are left neither will become of any size. Thinning at the stage of growth specified makes considerable difference in the future development of the crop. If left until the growth is considerable the plants are weak and spindling, due to their crowded condition, and thinning at that stage sets them back.

After the beets are thinned the soil is packed by the feet of the thinners and a cultivation is necessary, but this should be shallow, as the beets have not rooted sufficiently deep to withstand any considerable disturbance of the soil. The implements most commonly used are shown in figure 11, and consist of the knives and duck foot which cover about 10 to 14 inches between the rows, leaving a space of 3 or 4 inches next to the rows so as to prevent clods being pushed onto the plants. This cultivation removes all weed growth, except a few inches on either side of the row, and loosens the top soil to a depth of an inch or two. Following this cultivation at the interval of a few days, a second hoeing should be given, which will consist in not only removing the weeds between the plants in the rows and spaces untouched by the cultivator, but in working the soil as close as possible to the beet. After the completion of the second hoeing a second cultivation should be given going to a greater depth than the first one, and in place of knives a narrow cultivator shovel, called a deer tongue or bull tongue, is most commonly employed. By this time the beets should be pretty well up and showing their first heavy leaves.

To conserve the moisture in the soil, frequent cultivations and one more hoeing are necessary. Continued cultivation at this stage of growth is of the utmost importance and pays for itself many times over in the increased yield. It removes the weeds which may still come up, thus preserving all the moisture in the soil for the beets, keeps the land warm, and prevents evaporation by destroying the capillarity. The fields should be cultivated every seven to ten days at this stage, or after each rain, the depth increasing as the plants grow larger.

HARVESTING.

It is often the case that at the time of harvest the soil in the beet fields has become hard and dry from the irrigations without subsequent cultivation and the absence of rain. The selection of the implement to pull the beets depends largely on this condition. Figure 12 shows the ordinary beet puller, which is used where there is sufficient moisture in the soil or its nature is naturally loose, and it can be run to a depth sufficient to move the roots without breaking them near the surface and thus wasting a good portion of the crop. The prongs, as shown, run either side of the beet row and have a lifting effect which raises and loosens the beet. Two to four horses are required, depending upon the soil conditions and depths to which it is run. It is not sufficiently strong, however, aside from the damage it would do, to run in a hard, dry, clay soil. In such soils an implement similar to the one illustrated in figure 13, called a "beet plow,"

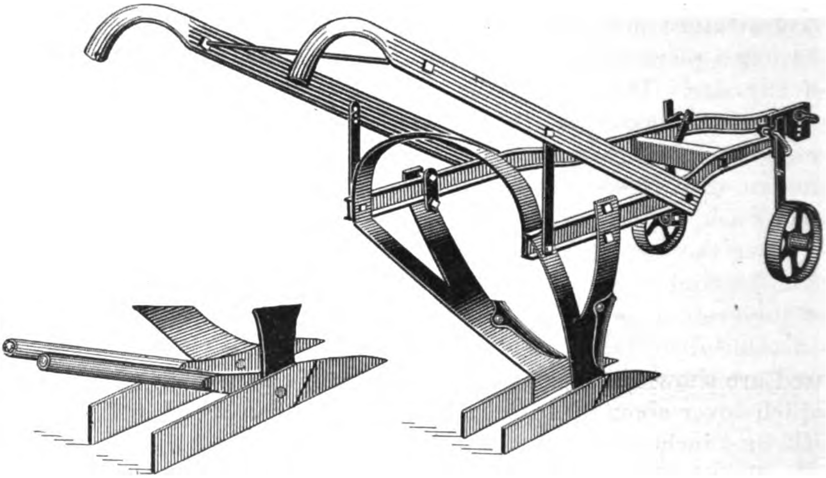

FIG. 12.—Beet puller.

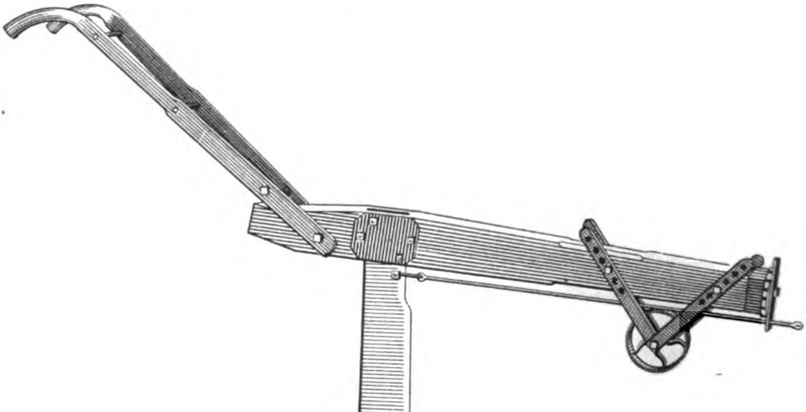

FIG. 13.—Beet plow.

is used. This consists of a heavy steel standard somewhat similar to a subsoil plow, to which are attached, at the bottom, a plowshare and land side, the moldboard being absent. This plow is run as close to the row as possible, with the land side next to the row so as to prevent cutting the roots. Four horses are attached and it goes to a depth sufficient to loosen the soil so that the beets will come out as nearly whole as possible.

Another implement is adopted in large fields. It is very heavy and six rows are pulled at a time. It is used in connection with the double engine plowing outfit and is handled in the same way as the balance plow, described above (fig. 3, p. 15); that is, an engine is stationed at either end of the field and the puller is drawn back and forth between them. The lifting or cutting tool is on the order of a duck foot or sweep, with wide side wings made of heavy material. It is run to a depth of 18 to 24 inches and cuts the roots off at that depth, as the wings overlap and cover all the ground below between the outside extremities. As much as 30 acres per day can be pulled with this outfit, but its use is confined to large fields on account of the cost of operating.

After the pullers or plows come the toppers with their long, heavy knives. Their first work is to throw the beets into piles, or windrows, after knocking them together to remove dirt. Six or eight rows, either side of the pile or windrow, are thrown together, and when the toppers are up to the puller or plow they go back to top the piled beets. One man is given a rake or hoe with which he clears and smooths the ground between the windrows or piles, upon which the topped beets are to be thrown, so that in forking them into the wagon no foreign matter will be included. The topping consists of removing, with a blow of the knife, the crown of the beet at the point of the lowest leaf and throwing the topped beet on the cleared space.

Picking the beets up for topping by either slashing into them with the knife or having a sharp hook on the end of the knife for this purpose is forbidden by most factories, especially in the colder climates, as it has been found to cause rotting of the roots thus injured. If they are picked up in one hand and topped with the other the work is just as rapid, and where beets are siloed the loss will be little or nothing.

Where the pulled beets are thrown into piles a pile of topped beets is placed in the center of a square of four piles of untopped beets. If the pulled beets have been thrown into windrows the topped beets, from 20 to 25 feet in two windrows, are thrown together into a pile. The disadvantage of the windrows is that the topper has to keep moving to reach the beets, while when the beets are in piles they are close at hand and he may kneel at his work. Sometimes the beets are topped as they are pulled from the row and thrown either into a wagon or into piles, but the method first described will be found to take little more time, if any, than the latter, while there is no comparison between the results. Care should be exercised that the pullers or plows do not get too far ahead of the toppers, as it is desirable that the plowed-out beets be cleaned up each night.

In most of the present beet-raising districts the piling method is practiced. The harvesting is naturally cumbersome and expensive and inventors have been at work for a number of years trying to perfect a machine that will do away with the handwork, pull and top the beets, and load or pile them by means of elevators. A great many contrivances of this nature have been tried, but none has been found satisfactory. Where yields are good one man can top 6 to 10 tons a day. As the weather is usually cool at the time of harvest in the Rocky Mountain region, it is necessary to protect the piles of topped beets from frost, so at night those which are left in the field are covered with beet tops. This is a good practice and as a rule is demanded by the factory. It prevents not only damage from frost, but also drying out and consequent loss in weight if the beets are left in the field for several days.

In hauling a large, heavily-built rack with hinged side boards capable of bearing a load of 2 to 6 tons is used. Where the soil is too soft to bear the weight of the heavy beet wagons, sleds with boxes of various dimensions are used, the beets as they are topped being thrown into the boxes and when these are full they are hauled to the road and loaded into the wagons.

Beet forks made especially for this purpose have short handles and heavy tines with points protected so as not to stick into the beet. The wagons are arranged in various ways for dumping. Some have a heavy shaft extending lengthwise of the running gear, by means of which the entire rack can be dumped sidewise. Other racks break lengthwise in the center and the beets fall on either side of the wagon. Arrangements are also made at the dumps whereby one side of the rack is lifted against the chute by means of cables operated by machinery and thus relieved of its load. The use of nets made of light rope with a heavier rope around the edge is also popular. The net is spread over the rack before loading and is of sufficient size to lap over the side of the rack all around. In unloading one side of the net is attached to cables operated by machinery which pulls it out of the bed and throws the beets on to the dump, the other side being attached to the wagon sides. All these methods are to obviate the necessity of forking by hand, which is a hard, tedious process, and factories throughout the country have adopted these various methods of saving labor for their growers, as well as expediting deliveries. At the factories the loads are discharged into the bins constructed for that purpose, but for shipping, elevated runways are provided close to the railroad track upon which the wagons are driven and the load dumped into flat cars. The most modern arrangement of railroad dump is a wooden platform at an elevation of about 15 to 20 feet, with runways at both ends, the grade of the runways being such that the heavily loaded wagons can be drawn to the platform without the aid of snatch teams. The chute which connects the platform to the car has a screen of heavy iron bars for a portion of its length, so spaced that sand, dirt, and trash can drop through, but no beets. The screen is provided with a hopper below, which conducts the foreign material in a load of beets to the wheelbarrow. A weighing station, presided over by a weighmaster from the factory, is provided at each dump close to one end of the runway. The load is weighed, driven up to the platform and dumped, and then driven back to the scales to ascertain the tare. To the tare is added the weight of the screenings from the chute. The wagons all bear the numbers given them by the factory field men and a record is made of the wagon number and its owner, so that it is unnecessary for weighmasters to inquire to whom beets belong. Platform scales are sometimes provided at each end of the runway, one for loaded and the other for the empty wagons, so as to prevent any delay in the weighing. From each load a sample of beets is taken in a bushel basket, the number of the load being marked thereon. These beets go to the factory where they are weighed, then cleaned with a brush, and green tops from improper topping removed, and weighed again. The difference is figured out in percentage, and a further deduction made from the load as determined by this method. This deduction ranges from 2 to 10 per cent or even more sometimes, according to the care in topping and the quantity of earth clinging to the beets. Where beets are paid for on a percentage basis these samples are further used to determine sugar content and purity. The process consists of slicing longitudinally a V-shaped piece to the heart of each beet in the sample, extracting the juice from these and making a determination with the polariscope. Weight tags are given to each grower for the loads delivered showing the net weight, less the screening, but the final tare, as determined in the factory, is usually ascertained later at the time of payment, unless beets are delivered direct to the factory, when the determination is made at once and shown on the tag.

A few of the less progressive factories do not provide weighing stations or elevated platforms at the shipping points, and each grower loads into his own car. This necessitates the use of a great many cars, delays in securing them at the proper time, and a general aggravation to the growers.

SILOING.

In the Rocky Mountain districts the harvesting of the crop usually takes place in October and November. The removal of the beets from the soil must be completed before the ground freezes and as the bins at the factories are not of sufficient size to store the entire crop, the piles of topped beets in the field are covered with earth to protect them, and this is called siloing. The process consists of making piles considerably larger and more carefully made than in topping for immediate delivery, each pile containing 1,000 to 2,000 pounds of beets. Earth is then shoveled over them to a depth of 5 or 6 inches, leaving a vent at the top, to prevent heating, on which a few beet tops are thrown. Should indications foretell exceedingly cold weather, more earth is piled so as to form a wall 10 or 12 inches thick.

If siloing is carefully done the beets will keep in good condition until orders for delivery are issued. As a rule, this is never later than January 31. If the soil cover is dry and the winter is without precipitation, some weight is lost in the siloed beets, but the extra amount paid by factories for such beets will, as a rule, fully compensate for the extra labor and loss. The smaller the silos the better the beets will keep, and piles of 1,000 to 1,200 pounds will be found preferable.

CROP ROTATION AND FERTILIZING.

The continued planting of any soil to the same crop will have the same effect on irrigated as on unirrigated land, the beet crop particularly being a heavy drain on soil fertility. Rotation, therefore, is an absolute necessity in maintaining the soil at its full productive capacity. This has been realized in all of the older beet-growing districts, and gradually a system is being evolved which will give satisfactory results. Alfalfa, the principal crop throughout the irrigated areas of the West, is the plant most used in rotation. It not only fertilizes the soil by its nitrogen-absorbing properties, but is deep-rooted and yields good returns. Methods of rotation as practiced in Idaho, Utah, and Colorado vary somewhat, but the best practice is very similar throughout and consists in the planting of beets for two or three years, depending on the fertility of the soil, followed by grain, which produces a heavy rank crop after beets, then alfalfa, or alfalfa with a nurse crop of oats. The planting of alfalfa with a grain nurse crop the first year after beets is not advocated, as the grain grows very rank and does not give the alfalfa much chance to develop, so the planting of alfalfa in the second year, with or without a nurse crop, is the best practice. The alfalfa is allowed to remain two to four years, three being the more general practice. It is then followed for one year by some cultivated crop, such as potatoes, melons, or corn, so that the weeds and alfalfa which remain may be destroyed to a large extent, and then goes back to beets for two to three years. The method of plowing up alfalfa used in Idaho is strongly recommended. This consists of dragging or railing the alfalfa when the second crop has reached the blooming stage and plowing it to a depth of 3 or 4 inches, turning the sod completely. The plowshare should be kept sharp so that all the crowns may be cut at that depth, and a good disk coulter on the plow will be necessary to prevent clogging. By turning over the alfalfa at this time the plants will be more nearly killed out by exposure of the roots to the hot sun and the leaves and stems would have an opportunity to decompose and store humus in the soil. By following this with a deep plowing in the fall the land will be in good condition for the next season's crop. Disking and irrigating, if the land becomes dry, should precede the fall plowing. Clover and timothy are used also in rotation, and along the California coast beans are largely planted before beets, the latter crop being followed by grain.

Subsoiling below the plowing for the first crop of beets in connection with the above rotation should be practiced, as it will loosen the subsoil, which becomes hard and packed from the previous crop. This is not so necessary with the following crops of beets, as the puller or beet plow answers the same purpose.

The only fertilizer extensively used is manure and results from this have been excellent. The feeding of cattle and sheep with beet pulp, alfalfa, the waste molasses from the factories, and the beet tops in the field is common practice. Beet tops, however, would serve their purpose better, doubtless, if left on the ground and plowed under, and this condition is nearly always imposed upon the tenants who rent land from the sugar companies. In southern California the tops are raked and stacked and bring good prices, ranging from $1 to $3 per ton, as feed for cows. A number of companies deliver pulp to their growers without charge, the amount delivered to any grower not exceeding 20 per cent of the weight of beets delivered by him. This permits the grower to feed a number of sheep or cattle during the winter and produces fertilizer with which he can enrich his fields. From 7 to 20 tons per acre are used, spreading it during the winter and plowing it in with the opening of spring. Where continuous cropping is practiced this fertilization is very important, and as a proof of its value the field of the Great Western Beet Sugar Company may be mentioned. This field, containing about 100 acres, has been in beets ever since the factory at that point commenced operations in 1901. The crops averaged between 16 and 20 tons per acre each year and have shown no signs of decrease, due to the heavy application of manure each year. Rotation, however, is the cheapest and most normal scheme and shows the best results. Proper methods in accordance with soil and climatic conditions must be studied and worked out gradually. The system described above has thus far proved successful in the regions mentioned, and it is therefore advocated as a basis in working out a better rotation.

CROP FAILURES UNDER IRRIGATION, AND REMEDIES.

Like all cultivated crops the beet has its insect enemies and diseases, but entire crop failures are unknown. A disease known as "blight," which seems to be peculiar to very dry years, is the most serious trouble with which the beet grower has to deal. All the older districts have suffered from it at one time or another. It shows its effect in the curling of the leaves and the discoloration of the sap and tissues of the root and usually attacks after thinning is completed. As it has occurred only at long intervals it need not be feared, except in periods of unusual climatic conditions. Another disease is a species of root rot which often attacks large, healthy beets and causes them to decay in a short time. This is somewhat similar to the die back in the cotton fields of the South and is never general throughout the field.

Insect enemies are numerous, but can be controlled by spraying, with the exception of those which attack the young plants at the time of sprouting. For these the only prevention is heavy seeding, so that a stand may be obtained even if many of the young plants are eaten. The Bureau of Entomology of this Department has published several bulletins on insect enemies of the beet and their control, which will be found of value in preserving this crop from insect depredations. Otherwise, crop failures are due entirely to insufficient work and attention on the part of the farmer and may be enumerated as follows: Poor leveling, poor plowing and preparation of the seed bed, thinning when beets are too large, lack of cultivation after thinning, permitting the fields to become weedy, and the improper application of water in irrigating, both as to the number of applications and the quantity of water used. In the latter case one fast rule can always be followed, and that is observing the moisture of the soil. If samples of earth, taken at depths of 6 or 8 inches, are pressed in the hands and maintain their shape, there is sufficient moisture, while if they crumble the crop is sorely in need of water. The latter condition should never be permitted to exist. Experience and close observation will decide on the best time to irrigate. Too much water is as harmful as too little, and without cultivation both are conducive to small returns.

WATER SUPPLY AND ITS USE.

The greater part of the area devoted to beet culture in irrigated sections is under gravity systems, the balance being under pumping plants. Notable among the latter is the Garden City district of Kansas and the bulk of the fields in California. The beets require irrigation during the months in which streams are at their lowest stage, and it is therefore important that an adequate supply be obtainable. The reservoir systems of northeastern Colorado show the excellent provisions which may be made for storing water for use when water is low in the streams. These reservoirs, which are of various capacities, are none of them of any great extent, and advantage has been taken of the various depressions throughout that section to make them, so that none represents any great cost. During the period of high water in the natural water courses, when there is very little demand for irrigation, the reservoirs are filled with water, which is held in reserve for later use. In extent this is the greatest beet-producing region in the United States.

Between the South Platte River and the mountains from Boulder to Sterling in Colorado, a distance of about 120 miles, there are nine factories, with a capacity of about 8,000 tons per day, and an area of 70,000 to 80,000 acres devoted to sugar beets each year. This is made possible by the excellent arrangement of the water supply. Good land with water rights will range in price from $150 to $250 per acre. Water rights on ditches are valued at $30 to $60 per acre, and where reservoirs are owned separately from ditches the rights entitle the owner to a certain number of cubic feet of water, in accordance with the number of shares owned and the quantity of water in the reservoir during the season. Water rights in the canals are usually based on a continuous flow of 1 cubic foot per second for each 50 to 100 acres for a period of 200 days (April 15 to November 1), which, if used continuously, would amount to a depth of 4 to 8 feet on each acre, but this quantity is never secured. The ditch supply is usually augmented by water from the reservoirs and an average use of water on the beet fields of this district is 24 to 36 inches in depth. The quantity applied at each irrigation depends largely upon the dryness of the soil and the manner of distribution and was found to be from 6 inches to 1 foot in depth. Where the larger amounts were used there was always considerable waste from the fields, and this may be said to be a condition common to nearly all irrigated areas. With careful handling and proper preparation of the surface a quantity equivalent to 6 inches or less of rainfall should be sufficient, even on dry soil, to thoroughly saturate the soil without waste. In seasons of drought, when the water supply is below normal, priority of rights of the canal companies plays an important part in the amount received, as those who have first rights are entitled to the full amount of their appropriation before later appropriators receive their share; but the renting of shares in canals and reservoirs by owners who have little or no use for the water is common and arrangements are generally made whereby all who need water for irrigation are supplied, although very often in limited quantities. Where water is rented from a reservoir the charge ranges from $50 to $80 for 1,000,000 cubic feet, or sufficient to cover about 23 acres to a depth of 1 foot. Besides the purchase of water rights, a yearly charge is made for the maintenance of canals which averages from 40 to 75 cents per acre, depending upon the work necessary to keep the system in good repair.

The southeastern Colorado field is also an extensive one and contains six factories in a distance of approximately 150 miles, or from Pueblo to Holly. With the exception of the Sugar City plant, about 12 miles north of Rocky Ford, all are in the valley of the Arkansas River and, including the above exception, receive their water supply from that source and its tributaries. Water rights and the quantities used are about the same as in the South Platte Valley, but winter irrigation is practiced to some extent on account of a more limited precipitation at that time. Here, again, the storage of flood waters in connection with the canal systems shows the far-sighted policy of irrigation companies, particularly in the case of the Twin Lakes Canal, which supplies the Sugar City district with water. Although the owners of this canal have a late priority in the river, which would greatly limit their flow in dry seasons, the two large reservoirs owned by them near Leadville, Colo., can be drawn on in the latter part of the season when the river is low and they therefore have an ample supply. Winter irrigation in this district is more common than in other sections of the State, and the country surrounding Ordway and Sugar City is one of the best and most productive beet-growing sections.

On the government project near Garden City, Kans., the charge for water rights is $35 per acre, with an annual maintenance charge of $2.75 per acre. The duty is 2 acre-feet per acre, or 24 inches, in depth. For a pumping proposition this is very reasonable. Appropriators diverting water from the Arkansas River at this point can not rely upon the supply, as the stream is often dry, so that such rights have little value, and pumping plants are in general use.

In the Bear River Valley of Utah the cost of a right to water is $35 per acre, with an annual charge of $1 for maintenance. Water is rented at $3 per acre per year. A right entitles the farmer to the use of 1 cubic foot per second continuous flow during the irrigating period for each 80 acres, or sufficient to cover each acre to a depth of 3 feet. Beet land with water rights has the same value as in Colorado.

The beet fields of Idaho are all in the valleys of the Snake River and its tributaries, and the supply of water is generally ample throughout the season and its cost lower than in the districts already described. The Payette and Boise valleys in Idaho have an unusually favorable situation, with a mild climate due to lower elevations. A large reclamation project of the Government is now under construction there, which will dispose of water to the farmers at $30 per acre, with an annual charge of 40 cents. This is somewhat higher than some of the private ditches, but is about the average in this section.

California conditions, as before mentioned, are distinct from those of any other field. The three factories in the great interior valley at Hamilton, Visalia, and Corcoran have been in operation such a short time that they need not be considered. The fields tributary to Alvarado, the oldest factory, need practically no irrigation, although the company controlling this factory is arranging to irrigate about 5,000 acres in the lower part of the Livermore Valley. The fields tributary to the other five factories, especially the one at Spreckles in the Salinas Valley, are irrigated to some extent, the water being secured almost entirely by pumping. The cost varies greatly with the size of the plant, the area under it, and the height to which the water must be raised, so that without going much into detail no accurate information can be given. The Spreckles Sugar Company makes a charge of $3.75 for each acre winter irrigated, which would mean one irrigation, using either the waste from the factory or pumping fresh water from wells or from the Salinas River. The amount used depends upon soil conditions, but an attempt is made to give sufficient, so that it will penetrate to a depth where it meets the moisture in the soil. As the land is checked permanently into basins, the checks are allowed to fill until all the land in each check is well covered. Irrigation while the crop is growing is rarely practiced in the neighborhood of the factory, but in the upper part of the Salinas Valley from Gonzales to King City it is a necessity in most years. During the season of 1908 the beets on this company's ranches near Soledad and King City received two irrigations with excellent results. Large areas are now being prepared for irrigation in this valley to produce beets for the Spreckles factory, which has the distinction of being the largest in the world, having a capacity of 3,000 tons of beets in twenty-four hours. These areas will all be served by pumping plants and their leveling and checking alone will mean an outlay of $20 to $30 per acre. In the beet fields of the southern coast region of the State winter irrigating is almost universal. At Chino, Los Alamitos, and Compton one irrigation, and on rare occasions two irrigations, are given the growing crop in dry years, slip-joint pipe, before described, being used. The cost for each irrigation varies from $2 to $4 per acre.

COST OF GROWING AND THE RETURNS.

The average yield per acre for this crop in the irrigated States is 10 to 12 tons, but this should not be taken as a basis for figuring returns, as it represents both good and poor farming methods. Those growers who by their industry and forethought have made a success in producing sugar beets can alone be considered, and it will be safe to say that their average yield per acre is approximately 17 tons. Yields as high as 36 tons per acre have been noted, and from 20 to 25 tons are not unusual. On a flat-rate basis $4.25 to $5.60 has been paid per ton, the latter figure for siloed beets, while where payments are based on the percentage of sugar and purity, as high as $6.75 per ton has been received.

The largest single item in the cost of growing this crop is the hand labor, consisting of bunching, thinning, hoeing, and topping. The usual price where all is included in one contract is $20 per acre. A number of growers offer a bonus to the contractor of so much per ton for every ton per acre above a certain yield, and thereby give an incentive to good and careful work. Where each operation is contracted for separately, the following prices are generally the rule:

Bunching and thinning	$6.00
Second hoeing	2.50
Third hoeing	1.50

Topping, when separate from the other operations, is arranged for at so much per ton, depending on the yield per acre, for the reason that a good crop will save the workers a good deal of time in moving around to their work. Fifty cents per ton for a 10-ton crop and up to 15; 40 cents above 15 and up to 20; and 30 cents above 20 tons per acre, are approximately the ruling rates.

Hauling to the factories or the railroads is generally arranged so that the distance does not exceed 5 or 6 miles. An average would be 3 miles, for which 50 cents per ton is generally charged.

From figures gathered throughout the district under discussion the following items of average cost are given, which do not include original leveling of the land, interest, and depreciation on farm implements, or fertilizing, nor is the interest on the original investment considered:

Cost and profit from growing sugar beets.

		Per acre.
17 tons of beets, at $5, flat rate		$85.00
Plowing land 10 to 12 inches deep	$3.00	
Harrowing, leveling, cultivating, and preparing seed bed	2.00	
Drilling in seed	.50	
20 pounds seed	2.00	
Cultivating five times, at 40 cents	2.00	
Furrowing twice	1.00	
Irrigating three times—labor	3.00	
Thinning, hoeing, and topping—contract	20.00	
Plowing out	2.00	
Hauling, at 50 cents per ton (17-ton crop)	8.50	
Water charge for maintenance of canals	.75	
Total cost of raising		44.75
Profit per acre		40.25

In California the hand-labor item is usually less, but the cost of water for irrigation is higher, so that the total is about the same. Generally speaking, an 8-ton or 10-ton crop will just about pay the expense of growing, while anything above that yield will be profitable, and as the tonnage increases the greater the returns in proportion. On smaller fields the grower and his family often do all or the greater part of the work themselves, so that they earn good wages besides the profit from a good yield. Where beet land is rented for cash $8 to $15 per acre is charged, which includes water rights, while for share rent one-fourth of the crop is the usual rate.

RESULTS OF EXPERIMENTS IN SUGAR-BEET IRRIGATION.

Early in 1905 several of the sugar companies in Colorado presented a request to this Department asking for an investigation into the growing of sugar beets under irrigation, which would tend to determine methods, time of application, and quantities of water necessary to obtain best results. Two points were selected for the experiment stations, land, water, and labor being furnished by the sugar companies cooperating. Loveland, representing conditions in northwestern Colorado, and Rocky Ford as typical of southeastern Colorado, were chosen. For the years 1905 and 1906 the Great Western Sugar Company was the cooperating party at Loveland, while the American Beet Sugar Company at Rocky Ford has assisted continuously during the past four years. The soil at the two places is similar, being a clay loam of good depth. The climate also is very much alike except for a smaller annual precipitation at Rocky Ford. Methods of irrigation differ in that the every-row system is practiced at Loveland and the alternate row at Rocky Ford. The number of cultivations given the beets and their care were better at the former place. In a general way the objects of the experiments were to determine the effect of different numbers of irrigations and different quantities of water applied at each irrigation and in the aggregate; the difference between the effect of the use of small lath boxes and open cuts in the ditch banks on the quantities of water used and the depth of percolation; the effect of alternate and every-row irrigation, both in open and boxed furrows; the effect of the number of cultivations both before and after irrigation and their general effect on yield, sugar content, and purity of the beets.

The various experiment plats were situated in larger beet fields and were under exactly similar conditions as to preparation of the soil, time of planting, etc. Each had an area of 0.5 to 1 acre, and they were separated by strips of bare land 6 feet wide, so that water applied to one would not affect its neighbors. Seven plats (fig. 14) were used, each of which received irrigations as follows:

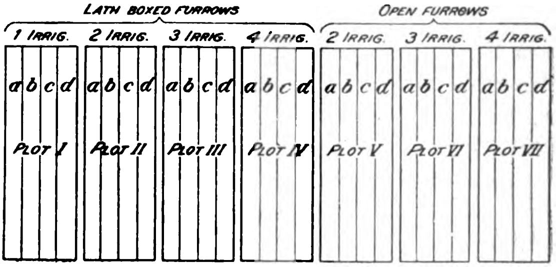

FIG. 14.—Plan of experimental field: *a*, Every row, no cultivation; *b*, every row, thorough cultivation; *c*, alternate row, thorough cultivation; *d*, alternate row, no cultivation.

Number of irrigations given to plats.

Number of plats.	Number of irrigations.	Method of irrigation.	Number of plats.	Number of irrigations.	Method of irrigation.
1	1	Lathbox, one-half every row; one-half alternate rows.	5	2	Open cut, one-half every row; one-half alternate rows.
2	2	Do.	6	3	Do.
3	3	Do.	7	4	Do.
4	4	Do.			

A record of all operations on a section of the adjacent beet field was also taken, the field being handled by the owner in accordance with his usual practice. Cipoletti weirs and recording registers were installed, so that the amount of water applied could be carefully measured. Beets were planted in rows 20 inches apart and thinned to as near 10 inches as possible.

At Rocky Ford, during the seasons of 1905 and 1906, the selection of experiment ground was unfortunate, and although the investigations bore out the conclusions as to results, the yield was low. In considering results obtained it must be kept in mind that the meteorological conditions vary from year to year, and that this has a large bearing on the yields. At Loveland the rainfall throughout the summer of 1906 was plentiful and well distributed, and two applications of water gave larger returns than either three of four applications, although as a rule the yield would increase with the number of irrigations up to a certain point, after which there would be a decrease. The experiments this year showed conclusively what would be expected—that with too much water the tops will make a rank, heavy growth without a corresponding development of the root. As the results this year are somewhat unusual as compared to those of the other years, they are given separately, as follows:

Effect of number of irrigations upon yield and quality of beets, disregarding methods.

Number of irrigations and plats.	Depth applied.	Average depth each irrigation.	Yield per acre.	Sugar.	Purity.
	Feet.	*Feet.*	*Tons.*	*Per cent.*	*Per cent.*
1	0.46	0.46	17.41	14.1	81.8
2	.94	.47	20.38	14.1	82.1
3	1.35	.45	17.45	14.0	83.2
4	1.69	.42	17.20	13.2	81.3

The seed was planted on April 6, and the rainfall during the growing period was as follows:

Rainfall, summer of 1906, Loveland, Colo.

Month.	Inches.	Month.	Inches.
April	4.06	August	1.07
May	2.21	September	2.95
June	1.80		
July	2.41	Total	14.50

This rainfall and the irrigation water constitute the moisture received during the growing season. Plats 3 and 4 showed throughout a very rank growth of leaves, and from their appearance one unfamiliar with the conditions would not have hesitated an instant in pointing them out as producing a heavier tonnage than either plat 1 or plat 2. When the beets were pulled, however, they were short and did not show a diameter through the thickest portion which was in any way proportionate with the top. Two irrigations were sufficient to produce the heaviest yield, while one gave better results than four. It is interesting also to note the effect of the use of lath boxes and open furrows with two irrigations in this experiment, as follows:

Yield of beets under alternate and every-row irrigation.

Method of irrigation.	Yield per acre.	Depth applied in two irrigations.	Average depth for each irrigation.
	Tons.	*Feet.*	*Foot.*
Lath boxes every furrow	24.58	0.86	0.43
Lath boxes alternate furrows	20.46	1.05	.53
Open cut every furrow	16.11	.92	.46

This shows a marked advantage in favor of the every-furrow irrigation controlled by lath boxes.

The year 1908, being abnormal, will not be included in the summary of results, but before discussing this summary it may be stated that an invesigation of this sort covers a wide range, which has been carried on to only a limited extent so far. It is, however, proposed to continue the work and determine the effects of many other practices, such as depths of furrows and cultivations, times of applying water, day and night irrigation, etc. It is hardly fair to base conclusions on the results from one year, as the foregoing has shown. The following summary gives three years' record of practically the same experiment:

Effect of number of irrigations upon yield and quality of beets, disregarding methods.

Number of irrigations.	Depth of water applied.	Average depth each irrigation.	Yield per acre.	Sugar.	Purity.
	Feet.	*Foot.*	*Tons.*	*Per cent.*	*Per cent.*
1	0.51	0.51	9.67	14.7	82.7
2	.83	.41	10.79	15.7	83.8
3	1.40	.47	11.78	14.9	82.5
4	1.62	.41	12.82	14.6	82.7

It will be noted that the sugar percentage under one irrigation is low, and this is accounted for by the fact that the beets had matured in the summer some time before they were harvested, due to lack of water to keep them growing. Samples taken at Loveland during 1905 show this to be the case. The field superintendent of the sugar company commenced taking these samples September 12 from all the plats, and continued to do so each week until they were harvested on October 12. It will be noted in the following table that plats 2, 3, and 4 (corresponding to the number of irrigations each received) increased in sugar and purity, as plat 1 decreased.

Sugar content and purity of beets at different dates.

Number of plat.	Date of sampling.	Sugar.	Purity.	Number of plat.	Date of sampling.	Sugar.	Purity.
		Per cent.	*Per cent.*			*Per cent.*	*Per cent.*
1	September 19	17.4	85.0	3	September 19	13.4	77.5
1	September 26	16.1	83.2	3	September 26	13.8	83.1
1	October 1	15.2	84.4	3	October 1	14.7	83.6
1	October 12	14.3	84.2	3	October 12	14.6	84.4
2	September 19	14.0	82.2	4	September 19	13.6	82.9
2	September 26	15.4	84.3	4	September 26	14.2	85.5
2	October 1	15.5	85.6	4	October 1	14.1	84.0
2	October 12	16.7	87.8	4	October 12	13.9	83.3

Two irrigations gave the highest sugar percentage and purity throughout, which is proof that these beets ripened better than the other plats, although the tonnage per acre for that year favors more applications of water.

The results of the use of lath boxes to control the distribution of water to the furrows, as compared with the open cuts in the ditch banks, are summarized as follows:

Effect of use of lath boxes to control flow to furrows.

Number of irrigations.	Method.	Depth applied.	Average depth per irrigation.	Yield per acre.
		Feet.	*Foot.*	*Tons.*
1	Box	0.48	0.48	10.77
1	Open[a]			
2	Box	.67	.34	14.10
2	Open	.68	.34	11.96
3	Box	1.53	.51	17.10
3	Open	1.15	.38	14.20
4	Box	1.67	.42	18.22
4	Open	1.70	.43	15.00

[a] No open furrows irrigated once.

The great discrepancy in tonnage between plats supplied by lath boxes and by open furrows can be attributed largely to deeper penetration of the water under the box method, due to its slow flow. Although the furrows were of equal length—an average of 350 feet—it required five to six hours for the water to reach the end of a furrow supplied by boxes, while one to two hours were sufficient where open cuts were used, and considerable waste water ran off the fields before the water could be shut off. If the water had been allowed to flow for an hour or so after reaching the end of the furrows there would not have been such marked difference in tonnage, but the amount of water used would have been greatly increased. This was found to be the case where results from the experiment plats were compared with those from the nearby beet field, on which nearly twice as much water was used for each irrigation as was used on the experiments. To say that the extra water was wasted entirely would be erroneous, for provisions were usually made to collect the waste in a ditch at the lower end of the field and apply it elsewhere, but there is conclusive evidence that the small-box distribution is far more economical than the open-cut distribution.

The results with the alternate and every row irrigation with boxed furrows were as follows:

Effect of alternate and every row irrigation on yield of beets.

Number of irrigations.	Method.	Depth applied.	Average depth per irrigation.	Yield per acre.
		Feet.	*Foot.*	*Tons.*
1	Alternate row	0.40	0.40	10.04
1	Every row	.57	.57	10.06
2	Alternate row	.96	.48	12.79
2	Every row	1.04	.57	13.98
3	Alternate row	1.16	.39	13.07
3	Every row	1.54	.51	14.07
4	Alternate row	1.41	.35	12.86
4	Every row	1.64	.41	13.92

It will be observed that in each case the every row irrigation shows an increase over the alternate row irrigation, and here, too, it is more than likely that if water had been permitted to run until it had met between the alternate rows the difference in yields would have been less, but this would have entailed the use of considerably more water and a consequent waste at the lower end of the field. It merely proves that for economical use of water better results can be obtained in every row irrigation than in the alternate row method. No accurate data can be given of alternate and every row irrigation with open cut-out, as it was impossible to so confine the water with this method that it would keep within the limits of the furrows.

A comparison of the neighboring fields which were handled in accordance with customary usage and the experiment plats fully proves the above conclusions, but it is possible to use only the results at Loveland during 1905 and 1906, as in the other years the comparisons are of little value, due to conditions which could not be foreseen. However, the fields reported in the table which is given below were adjoining the experiment plats and the general conditions were about the same. As stated before, the practice here is to use the every row method, with open cut-outs in the head ditch.

Comparison of experiment plats with adjoining general field, 1905–6.

Plat.	Method.	Number of irrigations.	Depth applied.	Average depth.	Yield per acre.
1905:			*Feet.*	*Feet.*	*Tons.*
Experiment plat No. 3	Every row; boxed furrows	3	1.37	0.46	16.78
General field	Every row; open cut	3	2.90	.97	14.00
1906:					
Experiment plat No. 3	Every row; boxed furrows	2	1.05	.53	24.58
Experiment plat No. 5	Every row; open cut	2	.92	.46	16.11
General field	do	2	2.82	1.41	21.13

There was no open-cut furrow experiment plat during 1905, so that the comparison there is lost, but the large amounts of water used on the general field during both years were due to the large heads and allowing the same head to continue for an hour or so after the water had reached the end of the furrow. Arrangements were such that no weir could be placed to measure the run-off in either year, so that this data is lost, but on the experiment plats sufficient water to reach only to the ends of the furrows was applied and there was little or no waste.

CONCLUSIONS.

The results of these experiments, as well as those obtained in practice at Rocky Ford, Colo., and in the Payette and Boise valleys, in Idaho, all point to the advantage of the control of the flow to furrows by lath boxes or pipes. The slowness with which the water moves permits of its deep penetration into the soil, prevents waste at the lower end of the field, and the use of the boxes saves considerable labor after they are once installed. Yields are better also, due to confining the water to the furrows and not permitting it to wet the top soil next to the beets. The thorough saturation which it gives is far better and less costly than a number of lighter irrigations, which are given in some of the localities. The number of irrigations needed depends largely on the season and whether the beets are paid for on a flat-rate basis or according to the sugar content. If on the flat rate, more water is required, but it must be remembered that keeping the soil continually wet will reduce the tonnage instead of increasing it, as the results at Loveland during 1906 clearly show, while there is the danger of ruining the land by raising the water table and producing a swamp. The beets under such conditions will be slow to ripen, and there is the liability of their refusal by the factory, due to too large size and low sugar percentage.

If a contract calls for percentage payments it will require a more thorough and careful understanding and study of conditions, so that both good tonnage and high sugar content may be secured. As has been shown, the beets must ripen at the time of harvest so as to contain their greatest values in sugar, and the application of water must be such as to cause a continuous healthy growth throughout the season, so that the tonnage is not sacrificed. A contract of this kind is equally beneficial to the factory and the grower who exercises care and judgment in the handling of the crop, which results in better returns on the average than the flat-rate contract. For example, a 17-ton crop at $4.50 per ton on a flat rate would bring $76.50, while if the same crop contained 17 per cent of sugar it would bring, on the percentage rate, $4.50 for 15 per cent, and an increase of 25 cents for each 1 per cent over—$5 a ton, or $85, which is equal to 11 per cent more than the flat rate.

The enormous consumption of sugar in the United States, amounting to more than one-fifth of the entire sugar production of the world, and the small quantity which is of home growth and manufacture, point to a field of large possibilities and the rapid colonization of the irrigated West.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 393.

HABIT-FORMING AGENTS:

THEIR INDISCRIMINATE SALE AND USE A MENACE TO THE PUBLIC WELFARE.

BY

L. F. KEBLER,

Chief, Division of Drugs, Bureau of Chemistry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., December 16, 1909.

Sir: I have the honor to transmit for your approval a manuscript prepared in the Division of Drugs, of this Bureau, on the indiscriminate sale and use of habit-forming agents, the investigation of that division having revealed the alarming extent to which such agents are used, and the large number of channels through which they reach the public, which is not informed as to their nature. I recommend that the manuscript be published as a Farmers' Bulletin, that this information, so intimately connected with public health, may be widely disseminated.

Respectfully,

H. W. Wiley,
Chief, Bureau of Chemistry.

Hon. James Wilson,
Secretary of Agriculture.

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HABIT-FORMING AGENTS.

EXTENT OF IMPORTATION AND USE.

Notwithstanding the fact that legislation, federal, state, and territorial, adverse to the indiscriminate sale and use of opium has been enacted during the past decade, and most physicians are using greater circumspection than formerly when prescribing opium, its preparations and derivatives, the amount of opium (exclusive of smoking opium, which is now denied entry into this country), consumed in the United States per capita, has been doubled within the last forty years. Not only has there been this increased consumption of opium, its preparations and derivatives, but large quantities of other habit-forming agents, introduced chiefly for medicinal purposes, have been used. For example, "cocain"[a] (cocain hydrochlorid), has been used for about twenty-five years, and the amount consumed at present is estimated at approximately 150,000 ounces per annum. In addition, it is well known that large quantities of acetanilid, acetphenetidin, antipyrin, phenacetin, caffein, and chloral hydrate, and smaller amounts of codein, dionin, and heroin are consumed. It should be noted that the amount of opium imported into the United States so far during the present decade indicates that the amount per capita is about the same as for the preceding ten years. Deterrent factors are undoubtedly antinarcotic legislation and publicity.

There are at present at least 100 sanatoriums advertising treatment for drug addiction, and it is well known that many thousands of cases are treated annually by physicians in private practice and general hospitals. The writer knows of at least 30 so-called mail-order "drug-addiction cures," some of which apparently have a large patronage. The manager of one of these treatments stated that his company had 100,000 names, including alcohol addicts, upon its books. The number of drug addicts in the United States is variously estimated by those who are conversant with the situation at from 1,000,000 to 4,000,000; the latter number is probably excessive.

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[a] The words "cocain," "codein," and "morphin," as used in this bulletin, refer to the salts of the respective alkaloids.

LABELING.

During the last ten years the writer has examined hundreds of preparations containing one or more habit-forming agents, exclusive of alcohol. It was not an uncommon practice in former days to represent to the consumer that such agents were absent, when as a matter of fact the very drugs named in the disclaimer were present. The reason for this subterfuge is plain. Normally no one desires to take preparations containing known habit-forming agents, which are frequently responsible for the use of, or demand for, the preparations containing them. During the last few years both federal and state laws have been enacted requiring a declaration on the label of the quantity or proportion of certain habit-forming agents when present in remedies intended for the treatment, mitigation, or prevention of disease in man or animals, but the consumer in many instances is not sufficiently conversant with the deleterious and harmful nature of these agents to avoid them. Again, these pernicious drugs are present in products which may not be classed as medicines within the meaning of the above definition.

CLASSES OF PRODUCTS CONTAINING HABIT-FORMING DRUGS.

It is the purpose of this bulletin to consider (1) representative preparations which in all probability dispose to habit formation; (2) preparations known to produce drug addiction; (3) nostrums laden with habit-forming agents to be used in treating drug addicts, including those addicted to the tobacco habit; (4) those who are primarily responsible for their sale and use, and, lastly, (5) some measures which will minimize or tend to eradicate the evil. The several classes of products will be considered as nearly as practicable in the order in which they are used, from infancy to old age. It should be stated at this point that only the most commonly used and known products of each class are considered in this bulletin, but others of the several classes are under investigation, and it is expected that the results will be published as soon as completed.

SOOTHING SIRUPS.

Soothing sirups naturally occupy the first place in such a list. Under this title will be briefly considered baby sirups, soothing sirups, "colic cures," children's anodynes, "infant's friends," teething concoctions, etc. It has long been known to the medical profession that these products as a rule contain habit-forming agents, but the majority of mothers have been and still are ignorant of this fact, although some degree of publicity has been given the matter during recent years. Lest any suspicion or fear should be aroused in the mind of the mother by the fact that the presence of opium, morphin, chloroform, cannabis indica, or some other harmful agent is declared upon the label, the manufacturer or dealer endeavors to allay such fear by statements of the following character: "Contains nothing injurious to the youngest babe;" "Mothers need not fear giving this medicine to the youngest babe, as no bad effects come from the continued use of it." Statements of the following character were also made in connection with preparations containing morphin or opium, or both, before the Food and Drugs Act went into effect: "This valuable remedy does not contain any opium, morphin, laudanum, or paragoric," and "It is free from all harmful agents."

Statements of this character have been largely eliminated, but in some instances they still appear in modified form either on the package itself, in the accompanying circular, or in masked form in newspaper advertisements. Notwithstanding the fact that these representations have been eliminated or modified so as to comply with the letter of the law, mothers, because of past representations and the fact that the false impressions left by them have not been corrected, believe that these soothing remedies are neither harmful nor habit-forming, and therefore give them with a certain feeling of security, with the result that in some instances the baby is put to sleep never to awake again. Numerous cases of this character are on record. In some instances, in which the remedy is freely used and the child does not succumb, there is developed a case of infant drug addiction. As soon as the effects of one dose pass away, the child becomes irritable and fretful, with the result that another dose is administered, the craving is met, and the child is quieted, a condition which is analogous in every respect to drug addiction among adults. Sometimes these children look plump and healthy, but as a matter of fact their flesh is soft and flabby and they withstand attacks of illness very poorly. The chief active agents of soothing sirups are well known to be opium, morphin, heroin, codein, chloroform, and chloral hydrate in some combination. The following are representative of this class:

Children's Comfort (morphin sulphate).
Dr. Fahey's Pepsin Anodyne Compound (morphin sulphate).
Dr. Fahrney's Teething Syrup (morphin and chloroform).
Dr. Fowler's Strawberry and Peppermint Mixture (morphin).
Dr. Groves' Anodyne for Infants (morphin sulphate).
Hooper's Anodyne, the Infant's Friend (morphin hydrochlorid).
Jadway's Elixir for Infants (codein).
Dr. James' Soothing Syrup Cordial (heroin).
Kopp's Baby's Friend (morphin sulphate).
Dr. Miller's Anodyne for Babies (morphin sulphate and chloral hydrate).
Dr. Moffett's Teethina, Teething Powders (powdered opium).
Victor Infant Relief (chloroform and cannabis indica).
Mrs. Winslow's Soothing Syrup (morphin sulphate).

It is hardly believable that anyone, for the sake of a few dollars, would concoct for infant use a pernicious mixture containing cocain, but several such mixtures have been found during the last year. One was offered for importation, under the name "Espey's Syrup for Children's Dentition," which contained one-half grain of cocain hydrochlorid to each bottle of about 1 ounce. The injuriousness of this product was a sufficient ground for prohibiting its importation into the United States. Another element of danger in the use of soothing sirups is the fact that nurses often use them, unknown to mothers, for putting children to sleep. Several well-known soothing sirups, it is reported, have been introduced largely by nurses in this manner.

Soothing sirups containing habit-forming agents, used without discrimination, undoubtedly leave their impression on the delicate organisms of infants and induce tendencies which under unfortunate circumstances in future life may be aroused to activity and develop an evil habit of one form or another. The question arises: How is this condition to be met? The signs of the times point to two ways, namely, education, and the withdrawal of the dangerous articles, both measures appearing to be necessary. At present there are on the market, intended to be used for children, several mixtures free from the customary habit-forming agents, but they apparently do not give satisfaction as formerly, as manufacturers are constantly receiving calls for the "old kinds."

MEDICATED SOFT DRINKS.

During the last twenty years a large number of soft drinks containing caffein and smaller or greater quantities of coca leaf and kola nut products have been placed upon the market. Preparations of this class, on account of insufficient information, were formerly looked upon as harmless, but they are now known to be an impending evil. Centuries before cocain was introduced as a remedial agent, wonderful accounts of the energy-creating properties of coca leaves were chronicled. The phenomenal endurance attributed to the Peruvians and others was often ascribed to the stimulating effects produced by the chewing of coca leaves, and this idea has been widely exploited. It is believed to some extent at present that the use of cocain taken internally produces a sense of exhilaration, and the amount of muscular and mental power appears to be temporarily increased. Impetus was given to this belief by the enthusiastic reports of the virtues of this drug, published not only in medical literature but in the secular press as well. Cocain is one of the most insidious and dangerous habit-forming drugs at present known. Many lives have been wrecked and many crimes have been committed as a result of its use, and strenuous efforts are being made to curtail its employment. The amount present in certain soft drinks is small, to be sure, but such an insidious, habit-forming drug certainly has no place whatever in these products. The presence of tropococain, an ally of cocain, has also been established. Not only is it most pernicious to add cocain to soft drinks in any quantity (usually in the form of coca leaf extract), but even the use of coca leaf extract so manipulated as to reduce the amount of cocain, or eliminate it altogether, must still be looked upon as a questionable practice, because any product or name which would suggest the presence of cocain or its allies, by taste or otherwise, must have a baneful influence. It is known that very small amounts of morphin or cocain, or even a suggestion as to their presence, will tend to destroy the equilibrium of reformed addicts and bring back the former craving.

The kola nut was prominently brought forward about twenty-five years ago as an agent for the relief of fatigue, but in this respect it has been a disappointment. For some time it was thought that the nut possessed some peculiar substance which accounted for this characteristic, but searching investigations showed that its chief active agent is caffein. Whatever virtue the drug possesses, therefore, appears to be due largely, if not solely, to this constituent. In fact, at present mixtures of caffein and burnt sugar are extensively used in preparing various caffein-bearing soft drinks, instead of the kola nut and its extracts. The caffein used is derived chiefly from waste tea leaves. The virtues of coca leaves and kola nuts have been exploited together, and it was only natural that they should be combined in preparations which would represent the purported virtues of both. Such combinations were made with the result that quite a number of so-called soft drinks now on the market contain both of the habit-forming agents, cocain and caffein. It is not uncommon to find persons addicted to the use of medicated soft drinks. It is

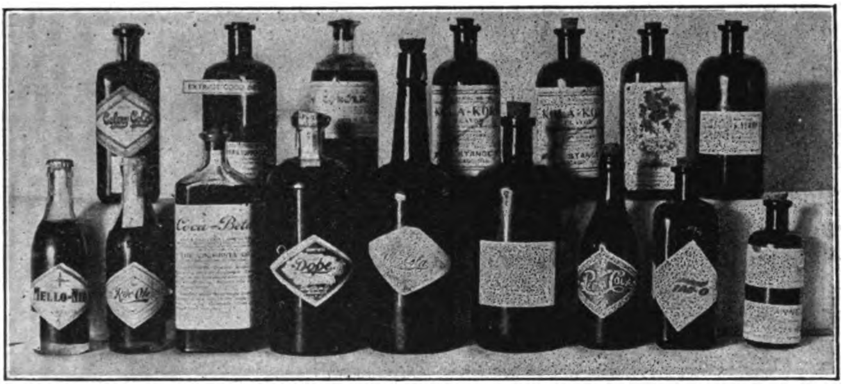

FIG. 1.—Some of the soft drinks containing caffein and coca leaf extract.

also a well-known fact that many factory employees, stenographers, typewriters, and others subject to mental or nervous strain spend a large part of their earnings for drinks of this character. In passing it may be of interest to note that life insurance companies are considering the status of soft-drink habitués as future risks.[a]

Various arguments have been advanced in justification of the use of caffein and the extract of coca leaves, treated or otherwise, in soft drinks. It is well known that parents, as a rule, withhold tea and coffee from their children, but having no knowledge of the presence of cocain, caffein, or other deleterious agents in soft drinks, they unwittingly permit their children to be harmed by their use. Manufacturers of drinks of this class, containing cocain, have been successfully prosecuted, for example, Koca Nola, Celery Cola, Wiseola, Pillsbury's Koke, Kola-Ade, Kos-Kola, Cafe-Coca, and Koke.

TREATMENTS FOR DISEASES OF THE NOSE AND LUNGS.

On account of their frequency, prominence, and difficulty of satisfactory treatment, diseases of the nose and lungs have received special consideration, not only by the best medical talent but also by charlatans entirely ignorant of the subject. The number of remedies concocted for the treatment of these afflictions is legion. Their vaunted values are, as a rule, dependent upon the presence of certain powerful drugs, such agents as cocain, chloral hydrate, codein, heroin, morphin, opium, and tobacco being present. Most prominent among the diseases for which such remedies are offered are asthma, catarrh, colds, coughs, consumption, and hay fever.

Asthma Remedies.

The exact cause of asthma is not definitely known by the medical profession at present. There is no known treatment which will eradicate the disease. The sufferer, however, is anxious to pay any price within his power to be freed from his infirmity, or at least to be relieved, which is the most that can be done by the most skillful physician. Notwithstanding this fact, numerous preparations are on the market which have in the past been represented as "cures," "infallible cures," "positive cures," and "specifics" for asthma, and these misrepresentations are still used in literature apart from the package, and in advertisements in newspapers, magazines, etc. Most of them consist of well-known substances in various proportions, among which are belladonna, stramonium, lobelia, potassium nitrate, potassium iodid, etc. There are, however, a goodly number exploited at present which have as their basic agents cocain, morphin, opium, or chloral hydrate. An example of the cocain type is "Tucker's Asthma Specific," which consists of a solution of cocain, and is sold throughout the United States as a result of extensive advertising and personal recommendation. The "Asthma Specific" consists of a bottle of medicine containing cocain, to be used as a spray with an atomizer. The price of the latter is $12.50. Recent investigations show that the amount of cocain purchased by the promoter of this remedy from a single manufacturing house during four months varied between 256 and 384 ounces a month.

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[a] A partial list of medicated soft drinks containing caffein, extract of coca leaves, extract of kola nut, etc., will be found in Senate Document No. 644, page 372, of the Sixtieth Congress, second session.

It is true that the amount of cocain introduced into the nose by means of a spray is small, but it is well known that exceedingly small amounts are required, when used in this manner, to produce constitutional effects. In fact, this is the popular manner in which cocain is taken by those addicted to its use. They are commonly known as "sniffers" or "coke sniffers" because of the fact that the cocain is sniffed into the nose.

Another instance brought to the writer's attention was the selling of cocain for the same purpose by a registered physician, who maintained that he had the right to send his treatment, as he called it, consisting essentially of cocain hydrochlorid, into interstate commerce to asthmatics and other persons similarly afflicted, without in any manner indicating upon the label of the package the fact that the preparation contained this injurious habit-forming drug.

Under existing laws, it is practically impossible to reach physicians engaged in practices of this character, provided they declare the presence of certain habit-forming drugs on the label and refrain from making false or misleading statements, for the reason that the state laws are so worded as practically to exempt physicians, and unfortunately there are a considerable number engaged in such dealings. If physicians of this type do not actually engage in the practice, they affiliate with some company or institution which is engaged in the business and in this way shift the responsibility and thus relieve themselves from liability under the present laws.

"Ascatco," an opium, arsenic preparation, represented as an Austrian product, is also largely used as a remedy for asthma and similar afflictions and enjoys a large sale. Another interesting treatment is known as "Davis' Asthma Remedy," put on the market by a dealer in real estate. The active agent of this commodity is chloral hydrate of which each dose contains from 1 to 8 grains. According to the directions: "Dose can be increased or diminished or taken as often as needed. If necessary, take as many as three doses all within fifteen minutes. Adults can repeat it as many as eight times in succession." On the label appears the following: "Tell others how it benefits you after using it." The conditions here are most propitious for the formation and spreading of the chloral habit. These examples give an idea of the character of the remedies at present being exploited for asthma.

Catarrh Remedies.

The remedies offered for asthma are, as a rule, advertised for the treatment of catarrh also, but certain special remedies have also been devised specifically for the treatment of this condition. These contain the same habit-forming drugs, the usual one being cocain. Previous to the enactment of state and federal laws requiring the declaration of cocain when present in a commodity, such products as Dr. Birney's Catarrh Powder, Dr. Agnew's Catarrh Powder, Dr. Cole's Catarrh Cure, Crown Catarrh Powder, etc., enjoyed very large sales. A number of the States, however, passed laws forbidding the sale of this class of mixtures except on physicians' prescriptions. It should be noted in this connection that the "catarrh cures" enumerated are, from the names, ostensibly devised by certain physicians, but there are good reasons for believing that no doctor of medicine has ever been connected with the introduction or promotion of these remedies. Several States required these concoctions to be marked "Poisons," which had a certain deterring effect. Many of the laws, however, were violated through some technicality, or rendered ineffective in other ways.

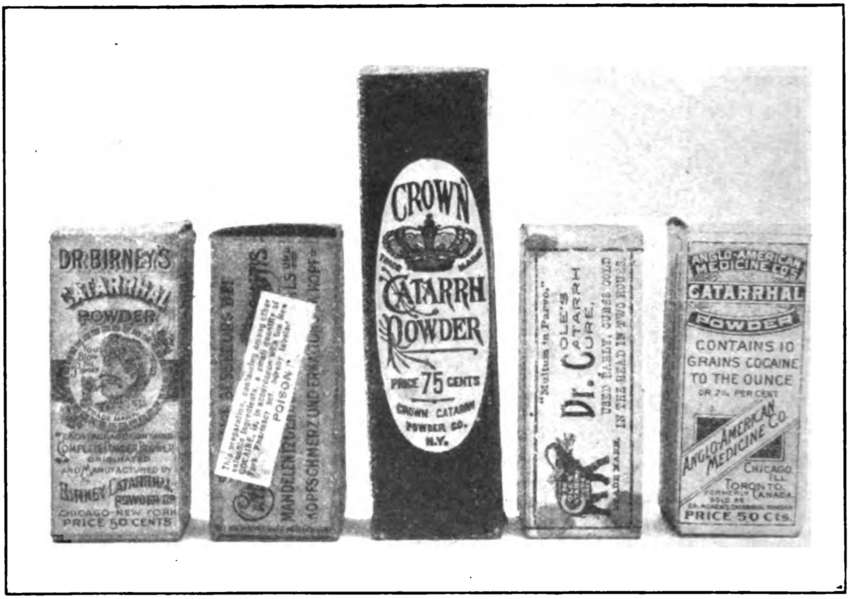

FIG. 2.—Catarrh cures containing cocain.

One of the conditions defeating the enforcement of the state laws was the fact that these pernicious products could be shipped in interstate commerce, without any information relative to the presence of cocain, to the addicts themselves or any other irresponsible person. When the federal Food and Drugs Act was passed it was apparent that products containing cocain or cocain derivatives must bear a statement on the label of the quantity or proportion contained in each ounce of the material, if shipped in interstate commerce or manufactured and sold in the District of Columbia or in territory subject to the jurisdiction of the United States. The result has been that most of these cocain-laden mixtures have been either taken off the market, sold locally, or shipped in interstate commerce by and through irresponsible persons. In some instances they are sent directly to the drug habitués by so-called reputable dealers. For example, a clergyman interviewed the writer some time ago as to the possibility of taking action against a certain firm supplying his communicants with a "catarrh powder," formerly known under the name of "Dr. Agnew's Catarrh Powder." He stated that the use of the powder was ruinous to some of his congregation and furnished the writer with the name of a large wholesaler in an adjacent State who furnished the remedy. A letter was written to this firm asking whether it would furnish Dr. Agnew's Catarrh Powder; and if so, what the charges would be. The firm was also advised that the reason for making the application was that the laws of the District of Columbia were so stringent and so rigidly enforced that it was exceedingly difficult, if not impossible, to purchase any cocain or cocain preparation in this jurisdiction. The firm in question responded to the effect that the desired article would be sent at a certain price. The amount named for three packages was transmitted by postal order and three packages of Dr. Agnew's Catarrh Powder were duly received.

Another case was that of a boy who had contracted the cocain habit. His father made inquiry as to whether it was possible for the federal authorities to interdict the sale of this commodity. He stated that in his home city the article was freely sold, and his son being known as a habitué, it was offered to him continually. The boy, about 18 years of age, stated that it was simply impossible for him to resist the temptation, and in order to save the family from disgrace he requested that he be sent into a country where cocain could not be purchased. He was accordingly sent to Germany, where he was at the time of the father's interview with the writer. It was also stated that the habit was contracted by the injudicious use of cocain in the treatment of catarrhal conditions by a reputable and well-known specialist. The father was anxious to bring his boy back to America, but was afraid to do so, owing to the ease with which this dangerous drug could be obtained.

The medical profession, state boards of health, pharmacy boards, and others interested in the public welfare have instigated what might be considered a crusade against the indiscriminate sale of cocain or mixtures containing it, but, owing to the fact that there are many individuals in the country who are more interested in the dollar than in the welfare of mankind, there are many ways found of evading the laws. For example, the druggist is not restricted in his purchases of cocain, and there is no law except in a few States requiring him to keep a record of the amount of cocain he handles in any given period of time. The result is that some druggists surreptitiously dispose of cocain to persons known to be addicted to its use, or others introduced to him by "cocain sniffers." These victims are well aware that if they give information of any character relative to their source of supply it will be cut off immediately, and the result is that the druggist can sell the commodity in this way with comparative security.

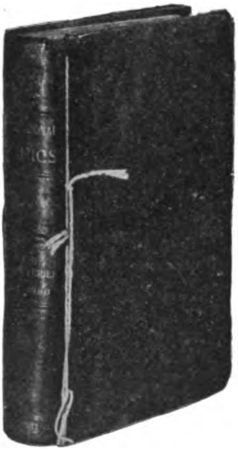

FIG. 3.—Book-box for surreptitiously peddling morphin (exterior).

Another source of difficulty is the so-called "morphin and cocain doctor." The laws permit the prescribing of these agents by doctors in their regular practice and to known drug habitués at their discretion or as the case may demand. The result is that in some cases there is little conscientiousness exercised in giving these prescriptions, and some doctors will write a large number of them for 25 cents each.

Another disturbing feature is the fact that some irresponsible persons obtain these commodities in various ways from others outside the jurisdiction of a State or the District of Columbia and peddle the same within a certain jurisdiction to their list of patrons. The ingenuity and cunning of these peddlers is astonishing. For example, one was discovered carrying about a supply of morphin and cocain in a book hollowed out for the purpose, as shown in the illustration. The edges of the leaves and one of the covers were glued together, and the body of the pages cut out, thus leaving a book-like box, which was innocent looking and well adapted for the business.

Cold and Cough Remedies.

Colds and coughs are among the most common ailments of childhood and youth, and many special mixtures have been devised and placed on the market for treating them. These concoctions usually contain one or more habit-forming drugs, as is clearly shown by the following examples:

Acker's English Remedy (chloroform).
Adamson's Botanic Cough Balsam (heroin hydrochlorid).
Dr. A. Boschee's German Syrup (morphin).
Dr. Bull's Cough Syrup (morphin, later codein).
Dr. Fenner's Cough-Cold Syrup (morphin).
Jackson's Magic Balsam (chloroform and morphin).
Kohler's One-Night Cough Cure (morphin sulphate, chloroform, and cannabis indica).
Von Totta's Cough Pectoral (morphin and chloroform).

The same habit-forming agents are offered to the public in the form of confections under such names as cough lozenges and pastilles; examples:

Linseed, Licorice and Chlorodyne Cough Lozenges (chloroform and ether).
Linseed, Licorice and Chlorodyne Pastilles (morphin, chloroform, and ether).
Pastilles Paneraj (morphin and codein).

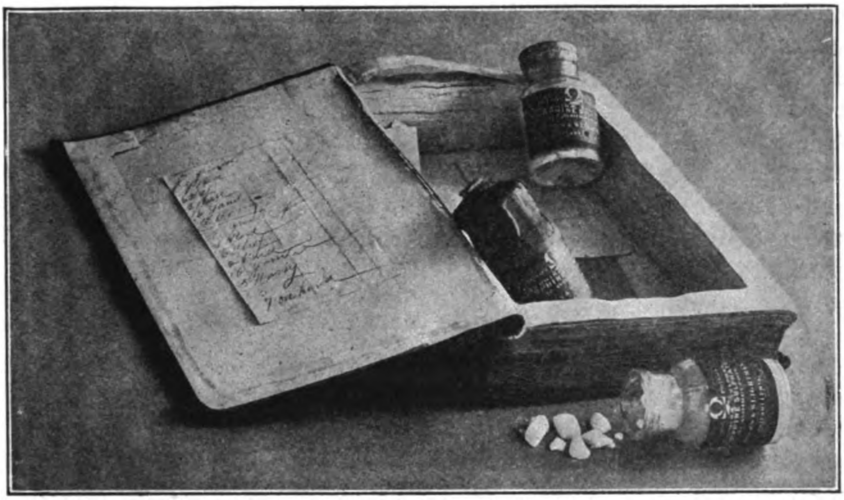

FIG. 4.—Book-box for surreptitiously peddling morphin (interior).

Products of the above character should not find their way into the hands of the public for indiscriminate use. Such a practice is uncalled for, as efficient cough and cold remedies can readily be prepared without the use of these pernicious drugs. The legion of ubiquitous headache mixtures are also exploited for these ailments.

Consumption Cures.

The exploiting of so-called consumption cures has apparently always been an inviting field to quacks. Promoters of these remedies are lavish in advertising them as positive and infallible cures. From the nature of the disease and the general information available to the public, it is only natural that persons so afflicted should grasp at the last straw.

These remedies as a rule contain one or more of the well-known habit-forming agents, the action of which is to benumb the sensibilities and thus make coughing and some of the other symptoms less prominent and distressing, leading the victim to the belief that the medicine is actually bringing about the results claimed. The ravages of the disease are, however, neither checked nor abated in spite of the fact that the patient appears to feel better. On the contrary, the poisonous secretions, instead of being expectorated, are absorbed, thus increasing the poisons, or, as they are commonly called, toxins, in the body. The most disastrous feature of the scheme is that the unfortunate sufferer is robbed of valuable time which could be utilized to advantage in restoring his strength and health. It is well known that if treatment is begun early the disease can be arrested, but not by using these worthless and deceptive nostrums. Hundreds of thousands of dollars are spent annually in a campaign of education and in the treatment of this disease, and it is of the utmost importance to get control of the cases early, as there is little hope in the advanced stages. Some of the well-known remedies of this class are the following: "Piso's Cure, a Remedy for Coughs and Colds," formerly known as "Piso's Cure for Consumption" (cannabis indica and chloroform); "Shiloh's Cure," formerly known as "Shiloh's Cure for Consumption," Dr. Brutus Shiloh (heroin and chloroform); "Prof. Hoff's Consumption Cure" (opium); "Yonkerman's Consumption Cure," called "Tuberculozyne" (heroin); and "Gooch's Mexican Consumption Cure" (morphin sulphate).

HEADACHE MIXTURES.

These mixtures are advertised as cures or effective treatments for many ills of mankind, ranging from cholera morbus in infants to "brain fag" and exhaustion due to drunkenness. They have been the cause of many deaths and hundreds of cases of poisoning.

The amount of acetanilid, acetphenetidin, antipyrin, caffein, etc., used in preparations of this class of habit-forming remedies is very large. Until recently it was claimed by some that these agents were harmless and did not belong to the habit-forming group. Later investigations, however, clearly show that this position is unwarranted. The medical profession for some time fondly believed that the depressing effects of acetanilid were counteracted by caffein, which is present in most headache mixtures, but pharmacological experiments have shown that the assumption is erroneous. The caffein in these mixtures may stimulate the heart to greater activity for a short period, but the depression induced by the acetanilid is persistent and increases in proportion to the amount used. Several preparations of this class, in addition to the usual ingredients, contain codein, a drug which is replacing opium and morphin to some extent. Representative products of this class are: "Royal Headache Tablets," "Antikamnia and Codein Tablets," "Ammonal with Codein and Camphor," and "Sal-Codeia Bell." The subject of headache mixtures has been treated extensively in previous publications[a] and the only object in referring to these remedies here is that none of the important links in the drug-addiction chain may be missing. These remedies in general simply benumb or stupefy the senses, but do not remove the cause of the trouble.

EPILEPSY REMEDIES.

One of the most pitiable and intractable diseases of mankind is epilepsy. There is no drug or mixture of drugs known to the medical profession which will eradicate the disease. The best that can be done for its victims is to diminish the frequency of the attacks by giving certain medicines and regulating the diet. These facts, however, do not deter the most ignorant from preying on these unfortunates. The various mixtures on the market contain one or more of the bromids, but a number contain, in addition, morphin or opium, the primary purpose of which is to create a demand for the remedy.

TOBACCO-HABIT CURES.

There are quite a number of so-called tobacco-habit cures on the market. All of them are ineffective, and some contain cocain in one form or another, which at once indicates the purpose of the promoter of the remedy. Instead of eradicating what is commonly believed to be a comparatively harmless habit, there is grave danger of fastening a pernicious drug habit upon the user. Examples of preparations of this character recently examined and found to contain cocain and cocain derivatives are Coca Bola, Tobacco Bullets, and Wonder Workers. The Coca Bola is marketed by Dr. Charles L. Mitchell, of Philadelphia, and the Tobacco Bullets by the Victor Remedy Company, now the Blackburn Remedy Company, of Dayton, Ohio, while the Wonder Workers were promoted by George S. Beck, of Springfield, Ohio.

DRUG-ADDICTION TREATMENTS.

With the exploiting and advertising of medicines containing habit-forming agents it is but natural to expect that drug addiction would result. It is only surprising that the number of cases is not greater. The reasons for this probably are, first, that the average individual is horrified to think of becoming a drug addict; second, the secret of many of the habitués dies with them; and, third, the most common cases, i. e., those using cocain, morphin, and opium, are short-lived, most of them dying within ten years after contracting the habit. The craving for the drug, with rare exception, can not be controlled or overcome as long as the drug is obtainable.

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[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 126, entitled "The Harmful Effects of Acetanilid, Antipyrin, and Phenacetin," and Farmers' Bulletin 377, on the "Harmfulness of Headache Mixtures."

There are at present "mail order express treatments" for all kinds of drug addiction. All correspondence and transactions take place through the mails except the sending of the "dope" itself. It is usually represented by the exploiter that the habit can be successfully treated at home, by the particular treatment he is interested in, and its composition is a profound secret, known to him alone. As a rule, these treatments are composed of well-known drugs. In most instances they contain the very drug or drugs for which the treatment is advertised and sold. For example, one physician furnished a treatment to a supposed morphin addict containing, according to his own statement, 22 grains of morphin to the fluid ounce, and in addition 4 minims of fluid extract of cannabis indica in the same amount (see fig. 5).

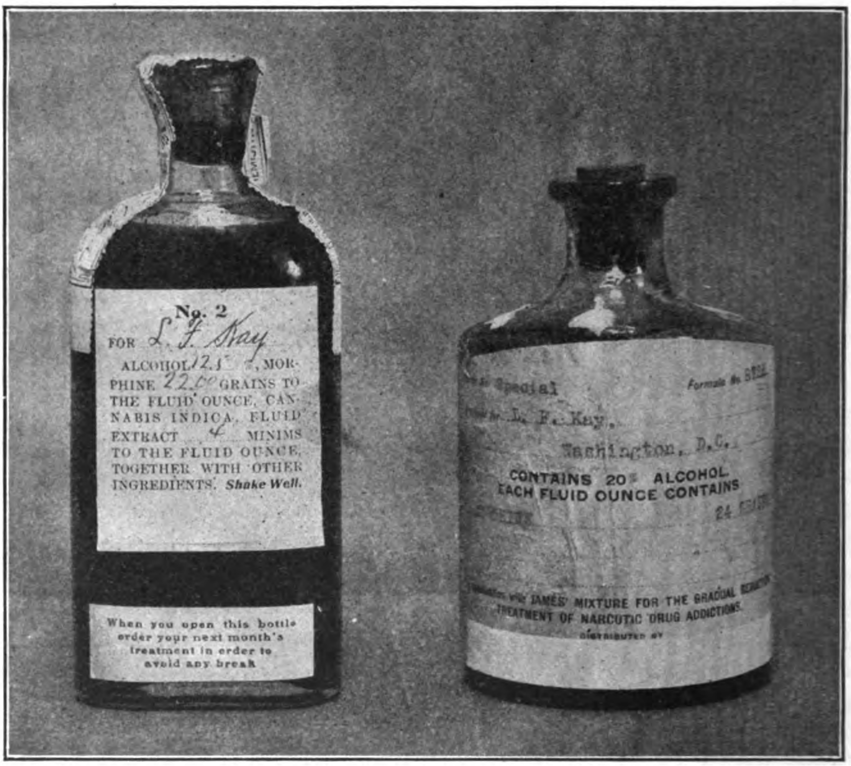
No. 2
FOR L. F. Kay
ALCOHOL 12.1 %, MORPHINE 22.00 GRAINS TO THE FLUID OUNCE, CANNABIS INDICA, FLUID EXTRACT 4 MINIMS TO THE FLUID OUNCE, TOGETHER WITH OTHER INGREDIENTS. Shake Well.
When you open this bottle order your next month's treatment in order to avoid any break
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FIG. 5.—Typical drug-addiction cures.

Another "doctor" supplied a mixture containing on the average 14.2 grains of morphin sulphate to the ounce. A package sent out by the James Sanitarium for the treatment of a supposed morphin addict contains 24 grains of morphin to the fluid ounce (fig. 5). A treatment of Habitina, supplied by the Delta Chemical Company, according to the label on the package, contains 16 grains of morphin sulphate and 8 grains of diacetyl morphin (the chemical name for heroin, a derivative of morphin) to the fluid ounce. An interesting practice in vogue is the sending of a supply consisting of a number of bottles marked from 1 to 18 inclusive, or whatever number there may be. In one instance, for example, 10 bottles were delivered marked "first supply," numbered from 1 to 10, inclusive, and every one bore the same inscription, namely, "Dionin 2⅔ gr., morphin 4 gr. per fluid ounce." Each bottle held about 4 ounces of fluid, which means that it contained 16 grains of morphin and about 10 grains of dionin, a morphin derivative.

There are at present at least thirty of these treatments sold throughout the United States. They are sent indiscriminately into any home, although some of them contain sufficient poison to kill a dozen men, and in only one instance has the writer observed a statement of warning relative to their poisonous character. Some of the promoters themselves have little knowledge of the dangerous character of the mixtures they are handling. For example, it was found that one of these treatments, handled by a groceryman who had neither medical nor pharmaceutical knowledge, was distributed to anyone asking for it. In some instances these men organized into firms or corporations and employed doctors to assist them in their nefarious business. The chief reason for employing a physician in this connection is to evade the various state laws, because a business of this character would probably be construed as practicing medicine, and such practice is denied to persons not legally qualified as medical practitioners. These physicians very well understand that there are at present no substances known to the medical profession which can be used successfully in the treatment of drug addicts without the careful supervision and restraining influence of the medical man himself and the constant attendance of a nurse acquainted with drug-addiction cases. It is well known that the drug addict is incapable of treating himself. The chief object of this practice seems to be to extract money from the unfortunate victims, who in many instances continue the treatment over a period of years.

In other instances the gradual reduction treatment is resorted to, but the reduction is very gradual, being in some instances at the outset 1 grain per month, when as much as 12 grains were used at the time the treatment was begun. In other cases no attention is paid to the progress of the patient, and if a second or third supply is ordered it is sent without question as long as the price is paid. This feature was clearly demonstrated by ordering from various institutions and individuals their various treatments; after a lapse of time, without giving any information as to the progress of the case, the second treatment was shipped without question or inquiry as to the patient's condition. Furthermore, in some instances the amount of opium or morphin present in the second supply is even greater than that present in the first.

Another very interesting feature brought out in connection with this business is the fact that the demand for the treatments is greater in States having stringent antinarcotic laws; for example, the laws of Texas or California or of the District of Columbia, Virginia, etc., relative to the sale or disposition of opium, cocain, and morphin, or preparations containing the same, are rather stringent and rigorously enforced, with the result that the demand for these drug treatments is greater in these jurisdictions than in certain other sections of the United States. In some instances even physicians evolve and operate the schemes. Some state laws contain a clause making it illegal for a physician to prescribe indiscriminately to habitués, but in cases of the character under consideration, where most of the material is shipped out of the State, little attention is paid to the business by the local authorities. It is obvious that unscrupulous physicians are the prime transgressors in fostering the perpetuation of these fraudulent so-called drug-habit cures.

SUMMARY.

There are various remedies on the market used from infancy to old age containing habit-forming agents which can be purchased almost ad libitum by anyone. Many of the mixtures are concocted, directly or indirectly, through the aid of unscrupulous physicians, so called. Some illicit sales of cocain, morphin, etc., are also made by druggists, both wholesale and retail. A few physicians take advantage of the authority intrusted to them for the proper using of these habit-forming agents and prescribe for all requesting them, regardless of the health and welfare of the public. Physicians often are not circumspect enough in the writing and safeguarding of prescriptions containing these drugs. With these conditions obtaining, drug addiction has become a great evil, and the question naturally arises, How can it be minimized or eradicated? There is a great diversity of opinion on this point, but the following are the lines along which results can be expected:

First. Educate the public through the press and by pamphlets, lectures, etc.

Second. Enact laws forbidding the sale of all pernicious habit-forming drugs, such as cocain, morphin, opium, heroin, etc., and their derivatives and preparations, at retail, except on prescriptions of physicians, dentists, or veterinarians.

Third. Require a permanent record to be kept, subject to state and federal inspection at all times, of all transactions in such drugs, whether wholesale, retail, or through the use of prescriptions.

Fourth. Enact laws forbidding the handling of any of these products except by manufacturers, wholesale and retail druggists, and others legally qualified.

Fifth. The state boards of health, or other governing bodies, should be empowered to withdraw the licenses of physicians who prescribe or druggists who sell these articles for other than legitimate medicinal purposes.

Sixth. A federal law should be enacted forbidding the shipment in interstate commerce of habit-forming drugs or preparations containing them, except through the customary channels of trade, and then only when complete records of all transactions are kept.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture.]

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 394.

THE USE OF WINDMILLS IN IRRIGATION IN THE SEMIARID WEST.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 31, 1910.

Sir: I have the honor to submit herewith material for a bulletin dealing with the practical phases of the utilization of wind power in securing water for irrigation, prepared under the direction of Samuel Fortier, chief of irrigation investigations, by P. E. Fuller, irrigation engineer. The Great Plains are being taken up by settlers who must, for the most part, farm them without irrigation, on account of the limited water supply. The rainfall in that section is always light, making this settlement to a certain extent hazardous. Large wind movement, however, provides a cheap source of power for lifting underground water for the irrigation of small areas, in connection with the farming of larger areas without irrigation. This material has been prepared for the purpose of assisting settlers in developing and utilizing power from the wind for irrigation. It is therefore recommended that it be published as a Farmers' Bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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THE USE OF WINDMILLS IN IRRIGATION.

INTRODUCTION.

Within the semiarid region there are millions of acres of rich, fertile land, now barren, some of which will be reclaimed through irrigation, but most of which can not be irrigated on account of the limited water supply, and must be farmed, if at all, without irrigation. The growing of drought-resistant crops, and improved methods of culture have done and will do much to make the farming of these lands less hazardous, but at best success is greatly threatened by droughts, which occur with greater or less frequency. This land is now attracting eastern farmers who are prone to risk failure in view of the possibilities in years of favorable precipitation. There have been many deplorable failures during the recent years which could have been averted had the unfortunate settlers fortified themselves against periods of drought by irrigating small parts of their land holdings. It is realized that to accomplish this requires an outlay of capital and if this outlay is great it precludes the possibility of such procedure.

With a view to helping these settlers, this Office has investigated the use of windmills as a means of pumping water for the irrigation of small areas in connection with the farming of more extensive areas without irrigation. It is the purpose of this bulletin to set forth in a simple, comprehensive way the possibilities of irrigation, using windmills only as a means of power.

SOURCES OF WATER SUPPLY.

Before choosing a location for a homestead the settler should investigate the underground water supply. This can be done with some degree of assurance by inquiring of those having wells in the vicinity. The points desirable to know are: (1) Depth to water level; (2) nature of material encountered in driving wells; (3) amount the water lowers in the well during pumping; and (4) kind of well, whether bored or dug. With this information some idea of the amount of water which can be expected in the vicinity can be formed.

In event that no such information is available, it is best to put down a temporary test well upon the highest point of land within the area embraced in the proposed homestead. A bored test well 3 or 4 inches in diameter will suffice to show the nature of the formations underlying the surface, and if the supply of water is good the well may be kept for permanent use. Certain formations yield good supplies, while others, though yielding permanent supplies, do not yield large quantities, and should be abandoned. Generally a coarse sand with numerous bowlders, if of some depth, will promise a large yield. Coarse sand, gravel, or fine sand alone, will yield satisfactory volumes of water. Sand and bowlders mixed with clay or lime are usually so close as to offer great resistance to the underflow, and possess limited voids or space for water between the particles. By filling a pail or can level full of the dry material encountered in sinking a well, and then pouring water from a similar vessel into that containing the material until it will contain no more water, the proportionate volume of the material that is void or empty space will be found. A very promising formation is one which contains 50 per cent by volume of voids or, in the above test, one which will hold one-half its original volume of water. If the formation be sandstone or a conglomerate, the quantity of water which can be secured will be very limited. The thickness of the water-bearing strata should be ascertained if possible, for upon this also depends the quantity of water obtainable.

QUANTITY OF WATER AVAILABLE.

The quantity of water to be expected from a well can not be stated definitely, though a 10-inch or 12-inch bored well penetrating 15 feet of bowlders and gravel or coarse sand and with properly perforated casing should yield 100 gallons per minute. A 15-inch well penetrating 150 feet of coarse bowlders and sand in which 60 per cent of the mass is voids may yield as high as 1,000 gallons per minute. Dug wells supply a larger volume of water than bored wells of the same depth, though they are impracticable and expensive where the water is far below the surface and where the water-bearing material is to be penetrated to any great depth, because of the necessity of pumping to keep the water down during the sinking and because of the great cost of excavation and curbing.

Where a good water-bearing stratum can be found at a small depth a dug well 6 feet square need not penetrate the stratum more than 10 feet to secure 100 gallons per minute, and where a small pump and gas engine are available for temporary use they may be employed in sinking the well to the desired depth, and by this means the well may be tested during the sinking, the digging continuing only so far as may be necessary to secure the quantity of water desired, which should be not less than 100 gallons per minute for ordinary irrigation windmills. It is desirable to sink the well in the driest time of the season, as the minimum rate of flow will then be secured and the necessity of sinking the well deeper when dry seasons occur will be averted.

WELL CASING.

If the well is to be bored and cased, it should be not less than 10 inches in diameter. For coarse bowlders, gravel, and coarse sand, use light drive pipe known as screwed casing, having butt joints.[a] The lower end should have a tempered-steel drive shoe. This casing should be perforated by drive-slitting, by punching, or by a wheel perforator after the casing is in place. Another casing equally well suited is a standard double stove-pipe casing which is a sheet-steel pipe riveted together usually in lengths 2 feet long. These lengths are slipped together with "staggered" joints as the work of sinking proceeds. At the lower or inserting end four or five of these joints are riveted together, double or treble thicknesses being used, and a drive shoe of tempered steel is riveted on. This casing should not be driven but inserted by the use of hydraulic jacks. Perforation of such casing is done after the well is completed, and can be done best with hydraulic jacks. This casing is recommended for wells 10 to 24 inches in diameter.

If the water-bearing material is coarse sand and gravel, either of the above casings may be used, though the slits must be made narrower than for coarse material. The light drive pipe above mentioned may be perforated before being inserted by drilling one-eighth inch or three-sixteenth-inch holes profusely through the lower lengths where the water-bearing stratum is encountered, though the great number of holes required makes the method laborious and objectionable and the holes may become clogged by the coarse pieces of gravel, thereby closing the perforations.

If the material encountered is fine sand or quicksand, there is but one practicable method of securing the water through perforations without permitting the fine sand to flow in and fill the well, and this is by the use of a strainer having extremely fine slits, but beveled on the inside so that any particles which enter the slits will pass on through. One type of strainer consists of a brass, copper, or iron seamless tube, milled or slotted from the inside. In another type the pipe of which the strainer is made is drilled with half-inch holes and then wound with wire having a trapezoidal cross section, the width of the spaces left in winding the wire depending upon the fineness of the water-bearing material. These spaces widen from the outside in, so that they can not clog. Sometimes the wire is wound directly on the pipe and sometimes it is wound over strips laid along the pipe, in order to give the water free circulation along the pipe.

The fine material which can pass such a strainer will be pumped from the well. It is claimed for these strainers that in allowing the fine material to pass they clean this material from the water-bearing gravel, thus improving the flow of water into the well, but leaving the coarser material to itself act as a strainer. In some instances where such strainers have been used 10 to 12 cubic yards of fine sand have been pumped from a single well in developing the natural strainer area in the surrounding stratum, and in one instance 1,200 gallons of water per minute is being pumped from a 9⅝-inch well put down in a fine sand formation, and depressing the natural water plane but 13 feet from normal. Such a strainer may be used with any of the types of casing mentioned except stove-pipe casing. After the well is completed the strainer is inserted and lowered to the bottom of the hole. The casing is then raised high enough to expose the entire length of the strainer to the water-bearing material. A tight joint between the casing and the strainer is made by having a lead ring on the upper end of the strainer, into which a conical weight is dropped, forcing the lead out against the inside of the casing (fig. 1). The bottom of the strainer is of course closed so that no sand can pass into the well. The top of the casing then projecting above the ground may be cut off. Attempts to use galvanized casing as light as 26-gauge iron, with hatchet-cut slits, as a substitute for a strainer in such fine material have nearly always met with failure, and while such casing has been inserted successfully in some instances its cheapness is the only feature that commends its use.

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[a] Butt joints are so threaded as to permit the ends of the pipe to pass halfway through the coupling and butt against each other at the ends.

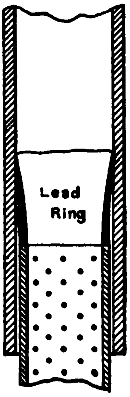

FIG. 1.—Method of making tight joint between casing and strainer.

Where the material encountered in boring a well is sand only, with no bowlders, it is feasible to use a light casing, say, 18 or 20-gauge iron, having knife slits punched in manufacturing; but even under such conditions it should be inserted inside a heavier casing after the well is completed, and the heavy casing should then be drawn, leaving the light permanent casing in place, thereby avoiding the strain due to driving and forcing the lighter casing.

Many wells fail to supply the proper amount of water because of insufficient perforation in the casings, and while no set rule can be given it is better to have an excess than not enough. The water in its passage through the water-bearing material meets with resistance, and the velocity is therefore slow. If only a limited area of perforations is provided, only small streams of water will enter the well and the pump will draw the water down until it takes air through part of a stroke, while the water level outside the casing will be but slightly lowered.

The writer has adopted the following general rules: Provide a total area of perforation in the casing exposed to inflow of ten times the sectional area of the casing if the bottom end remains open and eleven times the sectional area if the bottom of the casing be closed by being inserted into an impervious stratum. If fine quicksand be encountered, a greater area should be provided, say, fifteen or sixteen times the sectional area of the pipe. Care must be taken not to weaken the casing in perforating it when in place. The slits are usually 8 to 12 inches long, three or four slits being made in each ring or circle. A space of 4 inches is then skipped and a second ring or circle of slits is made, staggered from the preceding set. These perforations are of course made only in the water-bearing stratum.

SINKING WELLS.

While it is not the intention to discuss in this bulletin the sinking of wells, since this work is usually done by contract rather than by settlers, it may be well to make a few suggestions in connection with well drilling, and much time will be saved the farmer if he insists upon their enforcement.

BORED WELLS.

The sand bucket should be not less than 2 inches smaller in outside diameter than the inside diameter of the casing, and should have a steel shoe with a flap valve of as great an area as the bucket will allow. Often a well driller's outfit will contain a dilapidated bucket possibly 3 or 4 inches in diameter and having a round, worn-out, soft iron shoe, with a small valve in the bottom which is hardly one-half the size the bucket will allow, and, if permitted, he may attempt to sink a well 10 inches in diameter with such a bucket. Similarly, the bit may be too small for the well contemplated, and the result is that the casing is battered or punched by its side thrust. Another common cause for failure and delay is the attempt to drill ahead of the casing. Occasionally an attempt is made to drill the entire hole and insert the casing afterwards. While this may be possible above the water level, if the formation is hard and self-sustaining, or in oil wells, where much of the drilling is through shale or sandstone, the casing should be at the very bottom of the hole during the entire process of drilling when the formation is sand, gravel, or bowlders.

The writer has seen material removed from a well which would represent ten such holes; in one instance a cave was excavated which required 20 yards of concrete to fill the void. This was caused by the casing being hung while the drilling continued, in the hope that the casing would finally drop into place.

The use of hydraulic jacks is to be commended in all instances, as it permits continued drilling while a slight pressure is constantly exerted upon the casing thereby tending to keep it on a level with the work. If the driller's outfit be examined and proper tools be insisted upon before a contract is let for the well, much annoying delay to the farmer and expense to the driller may be avoided. Where wells are to be bored in sand, a method of jetting may be employed in sinking the well, which consists of forcing water under pressure through a small pipe to a jet at the bottom of the well which cuts out the material and causes it to rise in the casing as the work of sinking proceeds. This method is not, however, adaptable to the majority of wells, owing to the presence of bowlders and sometimes of slowly soluble material.

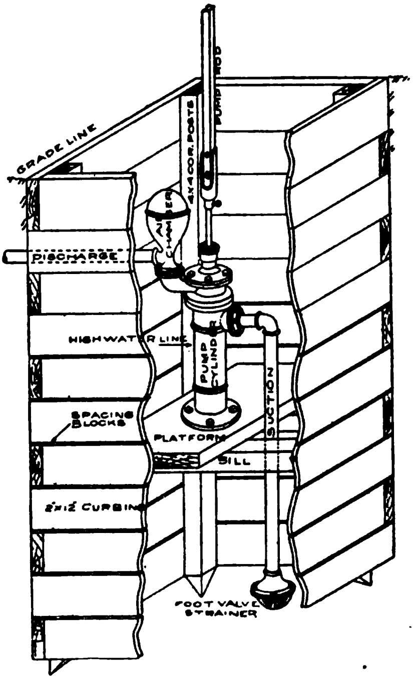

FIG. 2.—Wooden well curbing, with horizontal planks.

DUG WELLS.

Dug wells are too common to require a lengthy explanation. The curbing may be of timber, stone, or brick. Concrete has been used, though it shuts off the side or face area exposed to inflow. Stone or brick laid loosely provide the best curbing, though timber laid against corner posts and placed so as to leave narrow slits at the joints is a cheap and simple substitute for stone, but its life above the water line is short. If timber is used and the earth above the water line will stand without caving, 4 by 4 corner posts and 2-inch planking will be ample for depths up to 12 feet, but below the water line where caving is probable 4 by 4 side posts should be supplied in addition to the corner posts. Such curbing can be driven as the excavation proceeds. If the material throughout the entire depth is loose and tends to cave, a better plan is to frame bents of 6-by-6-inch timber, setting the plank curbing vertically back of the bents and following the excavation down by alternately driving each plank, which is sharpened from the inside, adding bents as the depth increases. The distance between the bents should not exceed 4 feet for depths up to 12 feet, and 2 to 3 feet for lower depths. Figures 2 and 3 illustrate such timber curbing.

WELL POINTS.

The use of well points is to be condemned where irrigation by windmills is considered, for the reason that the area exposed to inflow soon becomes obstructed by sand particles and is therefore entirely too small and the water supplied within the casing may be exhausted during even a small part of a pump stroke, leaving the remainder of the stroke to be supplied with air, or producing a partial vacuum. Further, there is a constant source of doubt as to whether the pump is securing the proper amount of water, or the slip is excessive, or the valves are failing to work. In cases where a small cylinder is pumping limited quantities of water for stock or for domestic use, and the depth to water is great, the use of a well point, if sufficiently large, may be allowable, though it is frequently the source of much trouble and should be avoided even in such cases if possible.

It should be borne in mind that what has been said regarding bored and cased wells refers to the semiarid region in particular, where, as a rule, the water occurs at a considerble depth below the surface. While the dug well is preferable, it is more particularly suited to shallow depths, and unfortunately favorable conditions for such wells occur only when the land is in proximity to a stream underflow, and such conditions are not characteristic of the semiarid region.

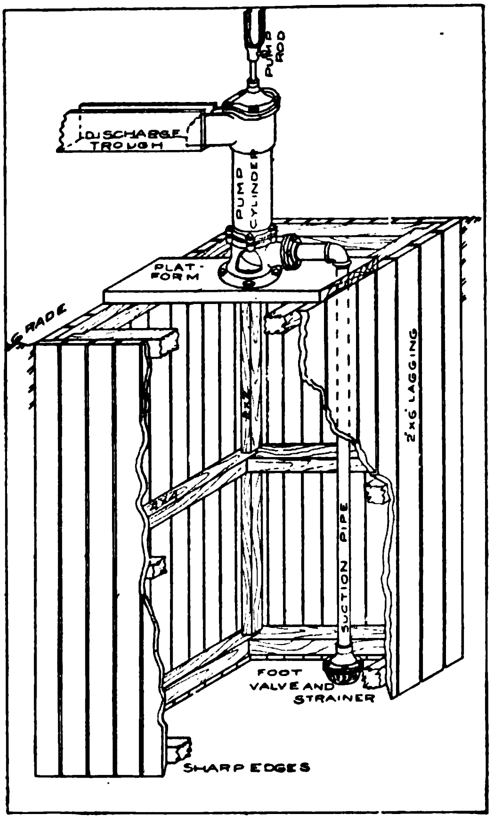

FIG. 3.—Wooden well curbing, with vertical planks.

It is evident also from the foregoing that if the bored cased well be used in shallow depths its diameter must be increased to permit the use of a pump of large diameter, so that a much larger volume may be pumped.

After the well is completed it should be tested for at least twelve hours continuously, though preferably longer, to determine the size of windmill and pump required. The quantity of water constantly flowing can be found by measuring with a bucket, or preferably with a weir.

CAPACITY OF MILLS.

The method of determining the size of mill to use and the principles involved, together with examples, are discussed below.

POWER REQUIRED TO PUMP WATER.

Figuring the horsepower required to pump a given quantity of water under known conditions is not a difficult problem, and anyone who is able to multiply and divide can make the calculation. One gallon of water weighs 8⅓ pounds. This multiplied by the total number of gallons to be pumped per minute gives the total weight of the water to be handled; this total weight multiplied by the number of feet from the water surface in the well while pumping to the center of the discharge pipe will give the number of foot-pounds of work to be done per minute. Now as one horsepower is considered as the energy required to raise 33,000 pounds 1 foot in 1 minute, the number obtained above divided by 33,000 will give the theoretical horsepower required to do the work. For example, if the water level in a well while pumping is going on is 25 feet below the surface of the ground, and the center of the discharge pipe of the pump is 3 feet above the surface of the ground, the total measured head to pump against is 28 feet. If the maximum volume to be pumped is 60 gallons per minute the weight of water is 60 times 8⅓, or 500 pounds. This number multiplied by 28, the total lift in feet, gives 14,000, the number of foot-pounds per minute, and this number divided by 33,000 gives 0.42, the required horsepower. This is the theoretical horsepower required in lifting water, and to this must be added the power lost in the pump by friction and slip and in the piping by friction. These quantities are never constant, varying with the different types and makes of pumps, the sizes of the suction and discharge pipes, the size of water ports into the pump, and the head under which the pump operates. It is possible to attain a pump efficiency as high as 70 per cent, but 50 per cent is more nearly the average under field conditions; that is, one-half of the power is lost in overcoming friction or in useless work, and to overcome this we must consider that the net horsepower computed is only one-half of the amount the mill must be capable of delivering to the pump, so that in the case cited above we must have a mill capable of developing 0.84 horsepower.

FRICTION OF FLOWING WATER IN PIPES.

If the water is to be carried some distance from the pump to a reservoir, then the pipe line conveying the water to the reservoir will offer friction to the flow, and this friction expressed in feet should be added in determining the total head against which the pump must operate. The following table shows the friction head in feet for pipes of various sizes when carrying different quantities of water:

Feet of friction head in clean wrought-iron pipe for each 100 feet of length when discharging various quantities of water.

Gallons per minute.	Friction head in pipe, with diameter of—														Size of pipe to use for economical distribution.
	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	10 in.	12 in.	
	Feet	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*
5	7.60	1.93	0.71	0.27	0.07	......	......	......	......	......	......	......	......	......	1.5
10	29.95	7.28	2.42	1 08	.28	0.07	......	......	......	......	......	......	......	......	2.0
15	66.12	16.08	5.48	2.23	.62	.14	......	......	......	......	......	......	......	......	2.0
20	116.12	28.33	9.37	3.82	.97	.30	0.07	......	......	......	......	......	......	......	2.0
25	179.71	43.77	14.74	6.03	1.53	.48	.23	......	......	......	......	......	......	......	2.5
30	......	63.36	21.08	8.64	2.09	.69	.28	0.07	......	......	......	......	......	......	2.5
35	......	85.24	28.56	11.63	2.90	.96	.32	.11	......	......	......	......	......	......	2.5
40	......	110.59	37.09	15.02	3.68	1.17	.39	.13	......	......	......	......	......	......	3.0
45	......	......	46.54	18.77	4.63	1.42	.62	.16	......	......	......	......	......	......	3.0
50	......	......	57.37	23.04	5.62	1.86	.80	.20	0.07	......	......	......	......	......	3.0
75	......	......	129.25	51.61	12.25	4.14	1.70	.48	.13	0.07	......	......	......	......	4.0
100	......	......	......	89.85	21.79	7.37	3.01	.76	.27	.11	......	......	......	......	5.0
125	......	......	......	......	34.33	11.26	4.58	1.17	.39	.16	......	......	......	......	5.0
150	......	......	......	......	48.84	16.12	6.56	1.58	.57	.23	......	0.05	......	......	6.0
175	......	......	......	......	64.74	21.79	8.87	2.18	.78	.32	0.07	.07	......	......	6.0
200	......	......	......	......	86.40	28.73	11.56	2.80	.97	.39	.18	.11	0.02	......	6.0
250	......	......	......	......	......	45.29	17.87	4.34	1.49	.60	.30	.16	.07	0.02	7.0
300	......	......	......	......	......	64.65	25.80	6.12	2.13	.85	.41	.20	.09	......	8.0

The length of pipe necessary to carry the water from the pump to the reservoir, expressed in hundreds of feet, should be multiplied by the friction head loss for each 100 feet, as given in the table.

It is well to select a size of pipe which will carry the maximum volume of water at a velocity of about 2 feet per second in the pipe line. The sizes recommended for a given volume are given at the right of the table. Suppose, for example, it is desired to deliver 60 gallons of water per minute through a pipe line 100 feet long. The table shows that a 3-inch pipe line delivers 50 gallons per minute at a loss of 0.8 foot head and a 4-inch line delivers 75 gallons per minute with 0.48-foot loss. The size desired is therefore between 3 and 4 inches, and as no intermediate size is made in wrought-iron pipe, the 4-inch pipe is best, and the total head to pump against would be in the example given 25 + 3 + 0.48, or a total of 28.48 feet.

It has been suggested that an open trough having a pitch or slope from the pump to the reservoir is preferable to a pipe line; but while this may be cheaper there is no saving in the head required, for if a trough be used the power required to raise the water high enough to flow to the reservoir through the trough is as great as that required to force it through the pipe. It may, in fact, be a little greater owing to the greater roughness of the trough as compared with the pipe line. Of course where the reservoir is adjacent to the pump a trough will be a more simple method of conveyance and it makes possible the use of a somewhat different type of pump, described later. The use of riveted pipe in lieu of smooth wrought iron is to be condemned because of the greater roughness and consequent greater loss of head.

TO DETERMINE SIZE OF MILL.

The feasibility of windmill irrigation depends much upon the head or height the water must be lifted from the well, and it is proper that a word of warning be given to discourage the use of windmills for irrigation purposes if the water table or level be over 60 feet from the surface of the ground; for, while the raising of small quantities of water by such power for stock or domestic use is perfectly feasible, the limited power of the ordinary mill is not sufficient to pump the large volumes needed for irrigation against a large head. As there is only a small percentage of time during which the wind attains a velocity favorable to the most economical mill load, the total quantity of water will be small at best, unless, of course, a very large mill is used.

On page 15 is given a table of wind velocities at Cheyenne, Wyo., during the months of April, May, June, July, August, and September for five years, 1904–1908, where six mills of various makes are installed for irrigation purposes. While the average monthly velocity in this section of the Rocky Mountain district is higher than in other localities farther south and east, the relation is not so different as to vary materially the corresponding calculated velocities elsewhere. To calculate the probable performance of a mill in a particular locality it would be well to secure from the nearest Weather Bureau office a report of the wind velocities for that district for several years and set down the various lengths of time that the wind has attained certain velocities. Then get from the manufacturer of windmills his guaranty as to the amount of power the mill will yield at the pump, together with the speed of the wheel in wind velocities ranging from 6 to 30 miles an hour.

It must be borne in mind that wind movement is never constant nor regular, frequently varying from a rate of 10 to 25 miles an hour within a few minutes' time. The methods commonly employed of measuring wind velocity do not take into account this continuous fluctuation because of the fact that the cup anemometer, however light, can not respond instantly to quickly varying impulses because of its inertia, and slowly loses its speed after a sudden impulse followed by a lower velocity. Consequently, only an average rate of wind movement is secured by such methods of measurement. The tabulation of the wind movement at Cheyenne, Wyo., covering the possible irrigation months during five years, 1904–1908, will serve as an example.

Wind velocities at Cheyenne, Wyo.

Year and month.	Hours during which the wind's velocity per hour was—								
	0 to 5 miles.	6 to 10 miles.	11 to 15 miles.	16 to 20 miles.	21 to 25 miles.	26 to 30 miles.	31 to 35 miles.	36 to 40 miles.	40 miles and over.
1904:	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*
April	136	207	187	111	49	19	6	2	3
May	158	281	154	97	36	14	4	....	....
June	200	300	151	47	10	12	....	....	....
July	245	293	139	51	15	1	....	....	....
August	249	298	124	59	14	2	....	....	....
September	284	300	89	39	7	1	....	....	....
1905:									
April	159	255	203	83	20	25	....	....	....
May	169	271	186	86	28	4	....	....	....
June	172	262	159	87	21	12	7	....	....
July	282	302	93	36	23	18	....	....	....
August	271	303	123	43	3	1	....	....	....
September	257	297	104	37	9	10	6	....	....
1906:									
April	125	297	167	67	38	24	2	....	....
May	188	253	165	79	30	21	7	1	....
June	156	220	166	79	52	16	15	10	6
July	310	313	102	13	6	....	....	....	....
August	265	299	134	37	6	3	....	....	....
September	208	308	130	58	11	3	2	....	....
1907:									
April	126	278	167	83	39	15	15	6	1
May	158	310	165	72	41	19	5	....	....
June	176	294	140	70	31	16	2	1	....
July	251	307	152	30	3	1	....	....	....
August	217	281	142	87	16	....	....	1	....
September	239	242	131	83	19	4	2	....	....
1908:									
April	151	244	146	101	38	17	18	13	2
May	143	249	171	95	60	19	5	2	....
June	198	283	147	50	34	6	2	....	....
July	260	346	107	24	7	.4	....	....	....
August	286	309	107	35	3	4	....	....	....
September	260	306	115	30	9	....	....	....	....
Total	6,299	8,508	4,266	1,869	678	287.4	98	36	12
Mean[a]	209.9	283.6	142.2	62.3	22.6	9.58	3.3	1.2	[b].4

[a] Per month.

[b] Mean at 43 miles.

In five years the wind during the months of April, May, June, July, August, and September had a velocity of less than 5 miles an hour for a total of 6,299 hours, or an average of 209.9 hours per month; it attained a velocity of 6 to 10 miles per hour during 8,508 hours, or an average of 283.6 hours per month. It attained a velocity of 26 to 30 miles during only 287.4 hours, or an average of only 9.58 hours per month.

Many mill manufacturers stipulate that their mills will perform certain work in an average velocity of 16 miles per hour during eight hours per day, but this is misleading and may result in an overestimate of the results expected, for while the average velocity may be 16 miles per hour the velocity for a part of the time may be too low to run the mill and for a part of the time too high to run it economically, thus producing much less power than a steady 16-mile wind. The average hourly velocity should not enter into the choice of a mill, but the time during which the wind reaches certain rates per hour should be the basis upon which a mill and pump should be chosen.

To illustrate this, the result of a test with a 14-foot power type of mill may be cited. In different wind velocities the mill was operated with varying loads, and the power developed and the number of revolutions of the wheel per minute with each load were recorded. These data were platted and diagrams were constructed showing the power developed (fig. 4) and the number of revolutions of the wheel (fig. 5) under different conditions. The following table shows for different wind velocities the loads under which the mill developed the greatest power and the speed of the wind wheel when the maximum power was being developed:

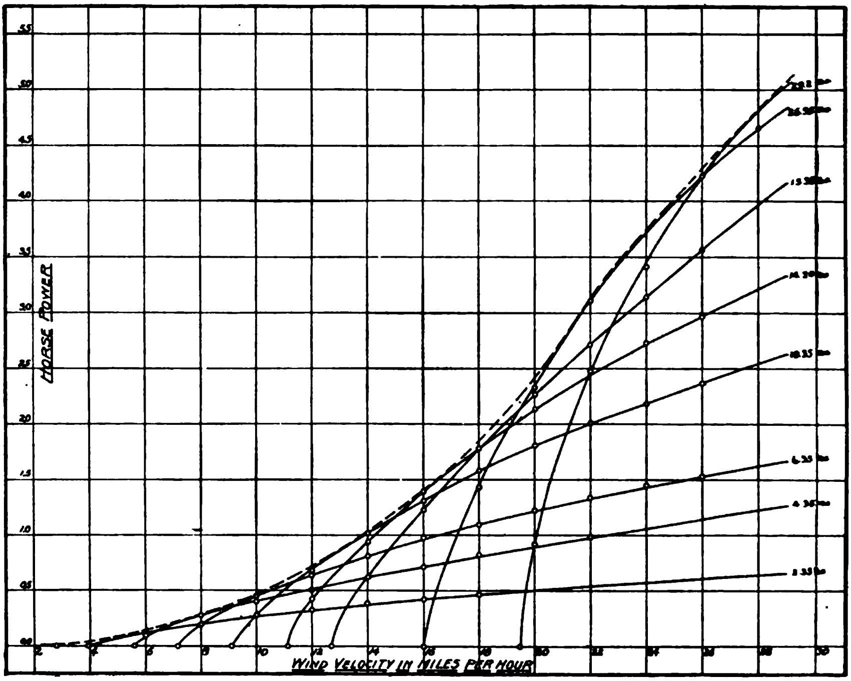

FIG. 4.—Diagram showing power developed by 14-foot mill with different loads in different velocities.

Loading and speed of 14-foot power mill when developing its maximum power.

Wind velocity—miles per hour.	Horse-power.	Speed of wheel—revolutions per minute.	Load in pounds per stroke.
0-5	0.01	2.0	....
6-10	.27	20.0	4.35
11-15	.85	29.5	10.35
16-20	1.80	38.0	14.20
21-25	3.45	45.0	26.35
26-30	4.82	51.0	29.20
31-35	5.60	55.0	31.00

From this table and the table showing wind velocities at Cheyenne it is possible to compute the work which could be secured from this mill. If it were possible to vary the load so as to utilize its maximum power, this mill would produce power during a month as shown in the following table:

Total power which could be developed by 14-foot mill, tested at Cheyenne, Wyo., if the load were varied to secure maximum power.

Wind velocity—miles per hour.	Horsepower produced.	Hours per month.	Total horsepower hours.
0-5	0.01	209.9	2.10
6-10	.27	283.6	76.57
11-15	.85	142.2	120.87
16-20	1.80	62.3	112.14
21-25	3.45	22.6	77.97
26-30	4.82	9.6	46.27
31-35	5.60	3.3	18.48
Total.	....	....	454.40

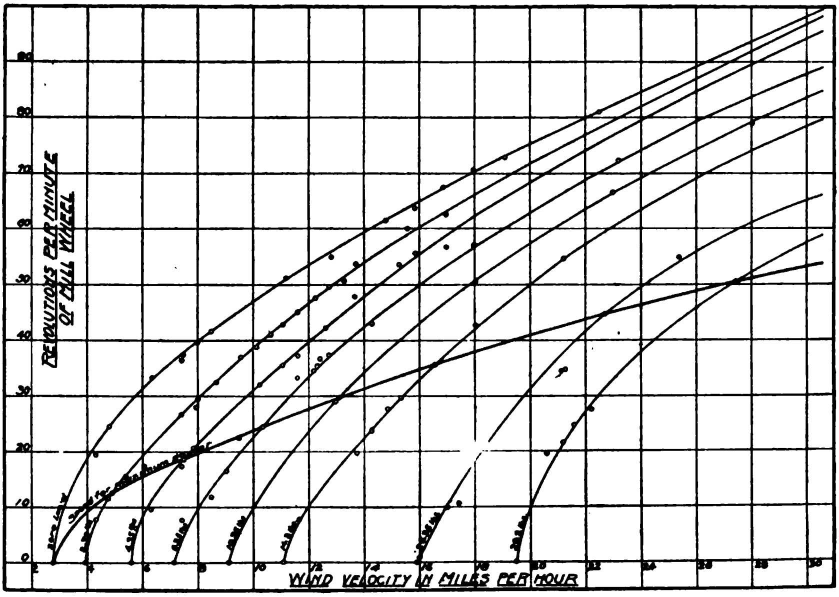

FIG. 5.—Diagram showing speed of wind wheel of 14-foot mill in different wind velocities with different loads.

Theoretically 1 horsepower will lift 3,961.6 gallons 1 foot in one minute, or 237,690 gallons per hour, and this number divided by the number of feet the water is lifted will give the number of gallons lifted per horsepower hour. With an efficiency of 50 per cent, which is ordinarily obtained, and a lift of 28 feet, this would be 4,244.5 gallons pumped per horsepower hour. As shown by the table, the total power produced per month was 454.40 horsepower hours, and consequently the total quantity of water which could be pumped under the conditions assumed would be 1,928,701 gallons, or 5.9 acre-feet, or 35.4 acre-feet for the six months of the irrigation season—enough water to supply 17.7 acres with a depth of 2 feet.

This, then, is the theoretical performance of this mill if it were possible to adjust the load so as to maintain the mill at its most efficient speed and if the pump efficiency were constant at 50 per cent. The former condition is not attained because the load—that is, the amount of water discharged per stroke—is constant, and to increase the work done by increasing the number of strokes in a given time would, with a fixed gear ratio, necessarily change the speed of the wheel from its most efficient rate; and, further, there is a limit to the practical speed at which a piston pump of that type can be run, which is about 40 strokes per minute. It might be supposed, naturally, that if the load is too small for the mill the small amount of water pumped per stroke would be compensated for by the mill making a greater number of strokes. While this is true to some extent, it should be remembered that there is but one economical or efficient speed for each wind velocity, and if the mill runs in excess of or below that speed it will do so at a loss of power.

If the load can not be varied with each change of wind velocity, the best economy will be obtained by adopting a cylinder which will load the mill at its most economical point during the greatest time possible. Again referring to the table of wind velocities, we see that if we load the mill to operate most economically in an 11-to-15-mile wind it will run during 142 hours per month at this economical load, but it will not run with economy in any velocities less than 11 miles an hour, and it will run less efficiently also during 62.3 hours in the 16-to-20-mile wind and during 22.6 hours in the 21-to-25-mile wind. But this underloading will tend to allow it to run so fast in higher velocities as to exceed the safe pump speed, and will therefore necessitate adjusting the mill so that it will "cut out" at a wind velocity exceeding 25 miles, thereby losing 64.65 horsepower hours of useful work per month. If the load be adjusted for the 16-to-20-mile wind, we can take advantage of operation at higher velocities, but this will entail a loss of 142.2 hours per month in the lower velocity. Hence it will be more advantageous to adapt the load to the 11-to-15-mile velocity.

Now, referring to the horsepower of this mill, it will be seen that it develops 0.85 horsepower in a velocity of 11 to 15 miles, running at a speed of 29.5 revolutions per minute. To pump 60 gallons of water per minute to a height of 28 feet, with a pump efficiency of 50 per cent, requires 0.84 horsepower, or 27,720 foot-pounds per minute. At 29.5 revolutions per minute the work done equals 940 foot-pounds per revolution of the mill wheel if it is of the direct-stroke type, and 2,820 foot-pounds per stroke if the mill is back-geared 3 to 1, because it will necessitate three revolutions of the mill wheel in this case to make one stroke of the pump, and the pump will be making only 9.8 strokes per minute instead of 29.5, as in the case of the direct stroke. As one-half of the load is considered as friction, the net water load with the geared mill will be but 1,410 foot-pounds. The total head that the pump operates against is 28.48 feet, and the number of foot-pounds of load divided by the number of feet head gives the number of pounds load instead of foot-pounds, as before. This, in the example, would be 49.5 pounds, and the cylinder should be of such size as will in one stroke discharge 49.5 pounds of water. Since 1 cubic inch of water weighs nearly 0.037 pound, the cylinder capacity would be 1,338 cubic inches, and this divided by the length of stroke in inches gives the area of the cross section of the cylinder. Most mills have provision for varying the length of stroke, but it seldom exceeds 14 inches. With this stroke the area of cross section of the cylinder is 95.6 square inches, requiring a diameter of about 11 inches.

The quantity of water that this mill would pump if it were possible to load it for the maximum effect in each wind velocity was computed on page 18, but it has been shown also that without some method of load regulation this is impossible, and that the nearest approach to this will be to load the mill so as to take advantage of the most favorable winds. The quantity of water which will be pumped under such loading with a cylinder having a 14-inch stroke and an 11-inch diameter will now be computed. On the horsepower curve No. 2 (p. 16) the curve designated 10.35 pounds gives the maximum 0.85 horsepower in the wind velocity of 11 to 15 miles per hour; and speed curve No. 1 (p. 17) shows that it requires a 9-mile wind to start the mill, so that in all velocities less than 9 miles per hour the mill will stand idle. The results will be as follows: In an 11-to-15-mile wind it will run at 29.5 revolutions per minute during an average of 142.2 hours per month; in a 16-to-20-mile wind it will run at 50.4 revolutions during 62.3 hours per month; with a wind velocity of 21 to 25 miles per hour it will run at a speed of 66 revolutions per minute during 22.6 hours per month; with 26 to 30 miles per hour it will run at 79 revolutions per minute during 9.58 hours per month; and with 31 to 35 miles per hour it will run at 86 revolutions during 6.5 hours per month. The mill would therefore make 608,640 revolutions during one month, or 3,651,840 revolutions during the six irrigation months. The mill being back geared 3 to 1, the total number of pump strokes will be one-third the revolutions, or 1,217,280 strokes, and as each stroke will discharge nearly 0.79 cubic foot of water, the total quantity of water discharged during the season would be 1,217,280 times 0.79, or 961,651 cubic feet, equal to 22.08 acre-feet of water, or sufficient water to apply 2 acre-feet to 11.04 acres of land.

If the pump is double-acting and discharges water on both the up and down strokes the cylinder should have one-half the area found for the single-acting type, or, in the example, nearly 8 inches in diameter in place of 11 inches, but the result will be practically the same. Should the total head pumped against be one-half that assumed in the example, then the power required to pump the same quantity of water would be less than one-half, or the quantity which could be pumped with the same power would be doubled.

Comparing the quantity which can actually be pumped with this mill loaded most favorably with the quantity it could pump if the load could be regulated, shows a loss of 14.92 acre-feet of water, or nearly two-fifths of the available power. It will appear to the reader no doubt that to load a mill properly requires a more thorough understanding of the problem than is within reach of the farmer; but if manufacturers of mills would provide ratings secured from careful tests which would show the speeds of their mills in different wind velocities and under different loads the problem would not be a difficult one and would involve merely a study of the wind movement for a particular locality to determine which wind velocities were the most prevalent and the most economical load for these velocities.

There is another feature in the choice of a windmill which is confusing to many—that of the difference between the direct-stroke and the geared type of mill. At Cheyenne a 16-foot direct-stroke mill and a 14-foot mill back-geared 3½ to 1 were tested under the same heads, the direct-stroke mill being loaded 413 foot-pounds per stroke and the geared mill 591 foot-pounds per stroke. The total work done is not materially different for these two mills. The direct-stroke mill requires a heavier wind to start, rapidly increases to its maximum, and rapidly descends from the maximum, while the geared mill starts easily, ascends to its maximum more slowly, and continues over a greater time. The conclusion is that the direct-stroke type is possibly a little better where the wind velocity is high for a considerable length of time, while the back-geared type is particularly well suited to high heads and average low-wind velocities. There is an advantage in the mechanical construction, however, in favor of the direct-stroke type of mill, as there is less machinery and consequently less wear than with the geared type.

The relative power of two mills of different diameters is about as the squares of the diameters of the wheels. For instance, if a 14-foot mill develops a maximum of 0.27 horsepower in an 8-mile wind, an 8-foot mill of the same type and relative area will develop $(\frac{8}{14})^2 \times 0.27 = 0.0881$ horsepower.

Much has been said concerning the choice between a large and a small mill wheel. Some mill makers recommend the use of a small mill in preference to a large one on the ground that, if a large mill is used, the water supply may become exhausted and the mill have to be shut down, while a small mill could be continued in operation at all times without exhausting the supply. Such an argument signifies a fault in the water supply rather than in the mill. No doubt, in view of the fact that the pressure upon a wind wheel increases as the square of its diameter, to resist the strain due to increased diameter, the strength of the mill must be greater and the tower also must be capable of safely withstanding the increased strain. Obviously, to secure greater strength of mill the weight must be increased and the friction loss must be similarly increased; but the increase of friction as compared with mill output will not be so great as it will be in case two small mills are put up with a combined power equal to that of the large one; and certainly the initial cost of one large mill will not be so great as that of two smaller ones. It is evident, therefore, that within reasonable limits the larger mill will be more economical in all ways and is the better size to adopt, providing of course that the water supply is great enough to supply the pump under average conditions of wind. Probably, however, under average conditions, a 16-foot mill will require a cash outlay greater than can be borne at the outset, and it may be better economy to limit the mill to 14 feet and, when a greater supply of water is required and circumstances permit, to install additional mills.

MECHANICAL FEATURES AND TESTS.

Before purchasing a mill it will be advisable to communicate with windmill manufacturers with a view to securing the best and cheapest mill suitable to the requirements. The following questions should always be given particular attention:

(1) Is the mill arranged to oil freely and amply?

(2) Are all parts subjected to wear arranged for easy adjustment?

(3) Are the gears (if geared) and parts heavy and well built?

(4) Has the firm which appears to have the best mill a good reputation for excellency of product?

A guarantee should be asked that the horsepower required will be delivered and maintained in given wind velocities. If it seems desirable to test the mill to ascertain its fulfillment of the guarantee, it can be done by computing the horsepower delivered by the pump, in the manner explained, in the different velocities covered by the guarantee. The wind velocity can be approximated closely by allowing a feather to be blown from the tower at the height of the center of the windmill. The distance, in feet, that the feather travels in a given number of seconds divided by this number will give the rate of travel in feet per second, and this rate per second multiplied by 0.68 will give the rate of the wind in miles per hour.

The power type of windmill—that is, one which transmits its power to a revolving shaft rather than directly to the pump rod—is a very desirable type to use for the reason that a heavy fly wheel may be attached so that the energy may be stored and applied to the pump during the working stroke, and the rotary motion makes the power available for running machinery of any kind. This type, too, permits the use of a double-acting pump, or a pump which delivers water on the downstroke as well as on the upstroke. This is not always practicable with the stroke mill, because of the flexibility of the rod and a tendency to buckle on the downstroke if much power is applied. The power type is usually geared forward in a ratio of four or five to one—that is, for each revolution of the wind wheel the horizontal shaft makes four or five revolutions.

Devices have been applied to equalize the work of the stroke type so that the mill will not be called upon to perform the entire work on the upstroke alone. While such a device tends to distribute the work throughout the greater part of the complete revolution of the crank shaft it does not increase the power of the mill, as is frequently claimed, for the reason that when the mill is loaded to its maximum the wheel acts in a measure as a fly wheel, tending to impart its stored energy at a time when the upstroke is being made; and if the load be greater at this period by virtue of springs so arranged as to store sufficient energy to operate a downstroke of a double-acting pump, the wheel must necessarily be slowed down in performing this additional work. Of course, if the mill be loaded inadequately in a given wind velocity, then the addition of such a device will utilize the available increase in wind energy which would be lost otherwise; but if the mill be properly loaded for its maximum effect, such a device is of no value.

LOAD REGULATORS.

On the preceding pages it was shown that for each variation in wind velocity the load of the mill should be varied if the total power developed is to be utilized. Several devices have been invented for accomplishing this. Some are operated by hand, but this fact alone makes them impracticable. The most successful of the automatic regulators is one which lengthens the stroke of the pump automatically as the wind increases in velocity and shortens the length of the stroke as the wind velocity decreases. If the stroke is shortened, the quantity of water pumped will be less in a given time and the power required will be reduced proportionately and the mill will continue to operate in a low-wind velocity, while if the length of the stroke be increased with the increase of wind velocity the quantity of water pumped will be increased proportionately without the accompanying thrust and strain upon the mill.

A careful record was kept of the mill upon which the stroke regulator was installed. A mean average of the day and night wind velocities was obtained by a standard recording anemometer, while the quantity of water pumped was measured with an integrating impulse water meter of a standard make. The pressure at which the pump discharged was found to average 52 feet total head. Curve *A* on figure 6 shows the average quantity of water pumped per mile of wind at various rates of wind velocities per hour before the stroke regulator was applied. Curve *B*, upon the same diagram, shows the results after the stroke regulator had been applied. The tests in both instances were of several weeks' duration. The wind velocities in all the tests are averages throughout the entire twenty-four hours each day, it being desirable to know the result of constant operation. Had the wind velocity been taken during the daytime only, the quantity of water pumped per mile of wind would have been higher, and the time of operation confined to eight hours per day, owing to the fact that the night velocities, while frequently too low to operate the mill at all, were recorded and added to the total wind in a given time. The average gain in water pumped through the application of the stroke regulator was found to be approximately 30 per cent, which gain represents the increase in water pumped in the same total number of miles in a given time. This regulator was loaned to the department for demonstration of its applicability to windmill work. If by certain changes in the mechanical construction its life can be assured, it will no doubt fill a long-felt want in the windmill field.

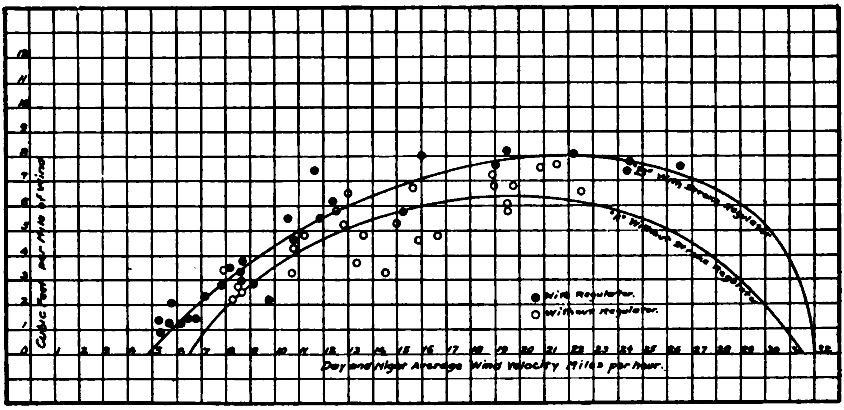

FIG. 6.—Curves showing quantities of water pumped by mill with and without stroke regulator. Head, 52 feet.

CHOICE OF TOWER.

The selection of a tower upon which to erect a mill requires no special suggestion, though it is to be regretted that some manufacturers are resorting to the use of pot metal in attempting to cheapen the cost of towers, and such inherent weakness has resulted in the loss of mills in sudden squalls which possibly would have withstood normally high wind pressures otherwise. It is well to use a tower which is amply strong to withstand the highest wind velocities, even though such strength may not be required ordinarily, as the damage resulting from failure will more than offset the slight additional cost for the added strength. The tripod, or three-legged tower, is lighter and allows trussing in a more correct manner, and even though the parts are proportionately heavier, the total weight is less than that of the four-post tower; but if the tripod tower is cheap or poorly constructed, it is more hazardous than the four-post tower of similar construction.

Careful attention should be given to the anchors and their footings. These should have plates of large area set upon a solid foundation and firmly tamped and bedded in place.

Wooden towers are good where clear timber is available at a reasonable cost, but unless they are substantially built and kept painted their life is short and they may fail at a crucial moment. If wood is used, the anchor posts should be firmly bolted to "dead men" laid across the bottom of the excavation, and the entire anchor should be well tarred or charred to prevent rapid decay.

The height of the tower has much to do with the success of a mill. It should never be located where the wind is obstructed in its free access to the mill, and it should be high enough above the ground to realize the full effect of the wind. Ordinarily 40 feet will give excellent results, though in some places the wheel may be set only a few feet above the ground.

ERECTION OF MILLS.

If more than one mill is used, the location with respect to each other should be given consideration, for if placed in line with the prevailing wind one will obstruct the wind considerably, even if they are placed at such distances apart as 500 feet.

When mills are shipped from the factory they are usually crated and require assembling completely in the field. Instructions always accompany the shipment and with care no trouble will be experienced in the erecting. After the mill is entirely assembled it should be inspected carefully to ascertain whether all the parts are placed correctly. In raising the mill it should be blocked up as high as possible and a 2 by 12 plank should be bolted upon the legs against the ground. Four by four sheer legs should be set astraddle of the tower about one-third up from the base, and over the crotch in these legs a stout cable or rope should be made fast to the mill head, the free end being fastened to a set of tackle blocks. Four-sheave and three-sheave blocks for 1¼-inch rope are best, one end of the blocks being made fast to the anchor. The free end of the line can be fastened to a doubletree and a team of horses can be used to raise the mill. Three strong guy lines, one in the rear and one on either side, should be made fast to the head so as to steady the mill when raising. Figure 7 shows a mill arranged for raising. It is well to choose a day for raising the mill when no wind is blowing.

PUMPS.

The speed at which pumps of the windmill type give the best results consistent with long life is at a maximum of 40 strokes per minute, but better results will be obtained if the length of stroke is increased beyond that usually adopted by mill manufacturers, leaving the cylinder diameter the same and reducing the number of strokes, but lessening the crank speed by gear reduction so that the quantity of water pumped per stroke is increased. The reason for this is that the column of water would be required to be started less often than otherwise, resulting in less wear and thrust in the pump and mill parts. In this respect a back-geared mill with greater reduction in gears and a consequent longer stroke would be preferable to the direct short-stroke type. Such an arrangement, however, requires that the gears be designed with ample face or tooth area and liberal strength in the parts. When the pump operates against a low head and through only a short and large pipe to the reservoir the objection to short strokes is not so serious.

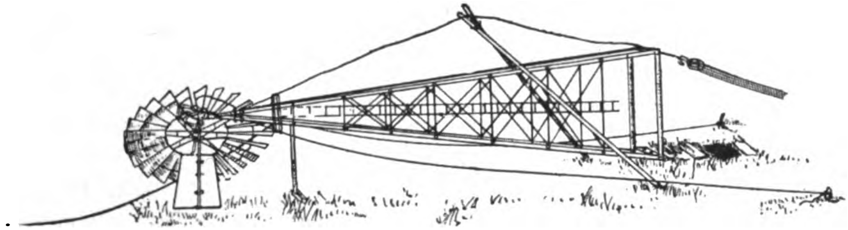

FIG. 7.—Mill and tower arranged for raising.

In choosing a pump for a particular mill the matter of size can be left to the mill manufacturer, but even in such case an understanding of the principles involved is most desirable, as investigation of mills and pumps shows that where no especial attention is given to the proper proportioning of pumps the results are most unsatisfactory.

A few points in the construction of a pump are of great moment to its successful operation and are given herewith.

(1) It should be insisted upon that the pump have a large stuffing box or gland (if it be of the pressure type) where the piston rod leaves the pump. This gland should be packed with a good grade of graphite packing.

(2) The cylinder or its lining should be of brass, seamless, and polished on the inner walls.

(3) The piston should have ample space for the best leather packing and the "follower" should be arranged so as not to become loose.

(4) The piston rod should be of bronze or heavily encased with brass casing, and in either case should be at least 1¼ inches in diameter.

(5) The guides for the crosshead should be of large diameter and be perfectly parallel to the piston rod in all positions.

(6) The ports or water openings through valves should be large and free.

(7) A generous air chamber should be provided at the discharge opening of the pump. Its capacity should be at least three times the capacity of the cylinder and a greater capacity than this will do no harm. This air chamber must be connected beyond the check valve in the discharge of the pump. In many pumps a small air chamber is provided on the pump, but as a rule it is located at the extreme top of the pump and the piston passes through the stuffing box at the top of the air chamber, and any leak in the gland or stuffing box at the top of the air chamber permits the air to escape and its usefulness is lost. A simple way of providing an extra air chamber is by inserting a horizontal swing check valve in the discharge line just outside of the pump and removing the cap or cover from the check and substituting therefor a simple flange. Into this flange a 3-inch or 4-inch pipe about 8 feet long may be screwed and a cap provided at the other end of the pipe (fig. 8). A small pet cock should be provided at the bottom so as to empty the air chamber of water

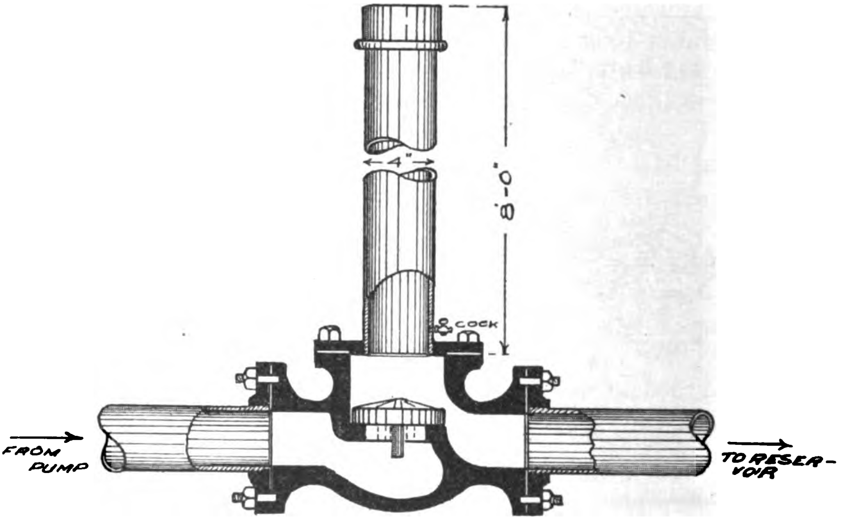

FIG. 8.—Method of combining air chamber and check valve.

occasionally, as the water will in time absorb the air compressed at the top of the cushion. Some manufacturers contend that a standpipe in the discharge pipe line located at the pump and having the free and open end projecting above the highest point on the discharge line gives better results than a closed chamber. This claim is fallacious in view of the fact that the inertia of the column of water in the standpipe is nearly equal to the impact of the horizontal water column in the pipe line to the reservoir, and the water hammer is therefore not lessened as with the air chamber, in which the gradual compression of an elastic body, the air, causes the impact upon the pump rod to be gradual and uniform until the stroke is completed, when the tendency of the air to expand to its original volume keeps the water column moving while the pump is making its return stroke. This is true even with a double-acting pump, in which instance the column would come nearly to rest otherwise, because of the slower rate of velocity of the piston at the end of each stroke.

If the suction lift is great and the pump hammers or pounds from this cause, a vacuum air chamber on the suction pipe close to the pump cylinder inlet will remedy the trouble. In such an instance no check valve is required other than that in the bottom of the pump cylinder. The result of such a vacuum chamber is to continue the column of water in the suction pipe in motion while the pump is traveling its downward stroke. At the suction inlet of the pump or at the end of the suction pipe a large strainer and check or foot valve should be provided which will prevent large gravel entering the pump and will keep it primed at all times.

If the pump is located close to the reservoir, it may discharge through a spout into a trough which carries the water directly into the reservoir. The pump in this case should possess all of the desirable features specified for the pressure type but needs no air chamber or gland in the pump head. In figures 8 and 9, pages 26, 28, pumps of both the pressure and spout types are illustrated in connection with the well curbing and serve to show the method commonly used in installing such pumps.

A pump of the pressure type, which is known as a siphon pump, is illustrated in figure 9. This pump possesses several unique features; the valves can be removed without pulling the entire pump apart, and the brass cylinder lining can be removed easily by taking off the pump bonnet or head. Another feature of this pump is that it always remains primed. However, it possesses the very objectionable feature of an air chamber at the top through which the piston rod passes. An additional air chamber as suggested above was provided for this pump at the Cheyenne station and gave excellent satisfaction.

When the water supply is very meager several pumps can be operated from one mill by an arrangement of bell cranks, though this plan offers many places for lost motion in the flexibility of connecting rods, and should be avoided if possible. Where the supply is very close to the surface and large volumes of water can be pumped owing to the low head, it becomes desirable sometimes to operate two pumps from one mill. In such cases, if the supply is sufficient, a reservoir is not imperative. The connection can be made by a lever not dissimilar to a seesaw arrangement having a pump at either end and the pump rod from the mill connected by a ball-and-socket joint at one end of the lever (see fig. 14, p. 43). There are not, however, many places where the water supply offers such possibilities, and even then a single pump of large diameter, even up to 36 inches, has been used successfully, and is no doubt much more efficient than the two-pump arrangement.

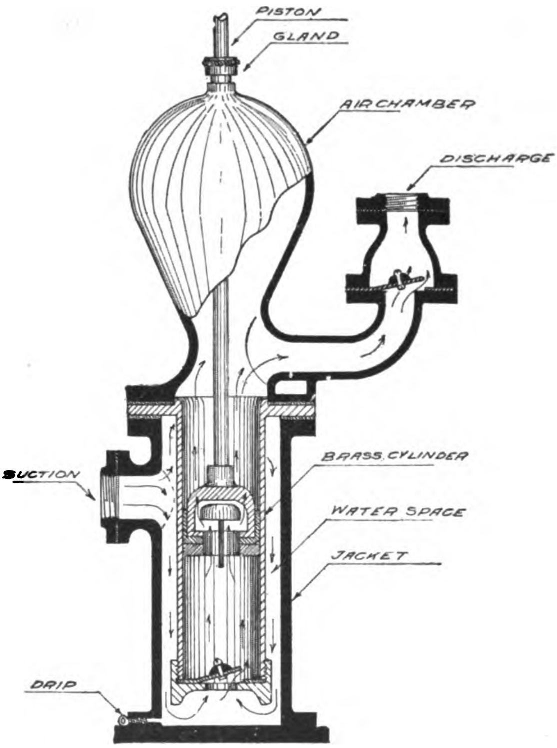

FIG. 9.—Siphon pump.

RESERVOIRS.

Probably the most important adjunct to a windmill plant is the reservoir. Indeed, a means of storing water which is delivered at a small rate of flow should be resorted to in every instance where the flow is less than 600 gallons per minute. The reason for recommending a reservoir for flows up to this amount is that, with small streams used direct from the pumps, the loss in conveyance in ditches is excessive and the loss in the application of the water to the land is large, since a small stream will saturate a spot and a large amount of water will sink into the soil in this one place instead of spreading over a large area and moistening the surface. Further, much more labor is required to irrigate with a small stream than with a large one.

If climatic conditions were favorable and resources not limited, there would be an advantage in having a reservoir which would hold all the water pumped from the time irrigation stops in one season until it begins in the next, for it is during the winter months that the greatest winds occur. Operation during the winter months would require only a large reservoir and the draining of pipes during calm, cold days or, better still, a frost-proof housing for the pump and piping. In many instances a reservoir can be made a source of profit during the winter months by producing ice.

The size and shape of a reservoir are important. A circular reservoir contains about 13 per cent less shore line than a square reservoir of equal area, and the surface of the water is less exposed to winds when the reservoir is partially filled. An oblong rectangular reservoir with one of its short sides toward the prevailing wind may have a smaller shore line exposed to wind, but it has a greater shore line, varying from 13 per cent up, depending upon the ratio of sides to ends, and in view of the fact that the seepage of water through the banks is approximately 20 per cent of the loss in the bottom of equivalent area it is desirable to reduce to a minimum the length of embankment. What has been said concerning shore line applies to the wave cutting of banks also. Round reservoirs in all sizes are more simple to construct. In orchards rectangular reservoirs conform better to the layout of plats, which are usually in squares or rectangles; but this does not offset the many advantages of the round ones.

The reservoir should be of sufficient size to hold the water pumped between irrigations. If the period between irrigations is ten days, and the pump delivers 60 gallons per minute on an average, the quantity pumped would be 864,000 gallons, or 115,500 cubic feet. The reservoir at Cheyenne lost about 10.5 per cent of its capacity in ten days, but this is not representative of earth reservoirs, which may lose 50 per cent in ten days. Assuming the loss to be 25 per cent, the capacity required would be 86,625 cubic feet, just a little less than 2 acre-feet. The reservoir should have some additional capacity to provide for the water pumped during a few days if irrigation is postponed for any reason.

Having decided upon the capacity of the reservoir, the next step is to decide upon the depth. In order that all the water in the reservoir may be available, the bottom of the reservoir must be above the land to be irrigated, and additional depth in the reservoir means additional lift for the pump and increased seepage losses per unit of bottom area, but, on the other hand, it decreases the surface area exposed to evaporation. No set rule for depth can be given, but considering all factors it is not deemed wise to make the depth of these small reservoirs more than 5 feet. Knowing the capacity desired and the depth, the area of the reservoir is found by dividing the number of cubic-feet capacity by the number of feet in depth. If the reservoir is to be rectangular, the area in square feet divided by the length in feet will give the width. If it is to be circular, divide the area in square feet by 0.7854 and extract the square root of the product to find the diameter. These statements apply to reservoirs with vertical sides, such as masonry or concrete walls; but the banks are ordinarily made of earth and must be sloped, the usual slopes being 2.5 or 3 feet horizontal to 1 vertical, and the diameter found above will be the diameter at one-half the depth. To find the top diameter, multiply the depth by the number of feet of horizontal slope to one vertical, that is, by 2.5 or 3, as the case may be, and add this product to the diameter at mid depth and subtract it to secure the bottom diameter.

The following table gives the dimensions of circular reservoirs of different capacities; the quantities of earth in the embankments, if these have inside slopes of 3 to 1 and outside slopes of 1 to 1; the areas which can be irrigated, provided the reservoir full of water is used once in ten days throughout five months and the land receives water to a depth of 1 foot; the sizes of mills recommended, and the costs of reservoirs and mills. The lift assumed in chosing the mills is 14 feet.

Sizes of circular reservoirs and estimated cost for various areas of land to be irrigated.

Gross capacity of reservoir.	Depth of reservoir.	Diameter at bottom of embankment.	Diameter at top of embankment.	Bottom width of embankment.	Top width of embankment.	Amount of fill required.	Number and size of mills recommended.	Estimated cost of reservoir.	Estimated cost of plant erected and completed.[a]	Area irrigated.
Acre-feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. yds.*				*Acres.*
0.07	4	21.30	45.30	19	3	212.00	1 8-foot..	$21.20	$81	1
.16	4	34.96	58.96	19	3	281.52	1 8-foot..	28.15	88	2
.24	4	45.62	69.62	19	3	336.25	1 10-foot.	33.62	113	3
.32	4	54.61	78.61	19	3	381.88	1 10-foot.	38.18	119	4
.40	4	62.27	86.27	19	3	422.46	1 12-foot.	42.24	202	5
.49	5	58.58	88.58	24	4	684.71	2 10-foot.	68.47	228	6
.56	5	63.64	93.64	24	4	725.80	2 12-foot.	72.58	392	7
.63	5	69.00	99.00	24	4	747.75	3 12-foot.	74.77	550	8
.72	5	74.37	104.37	24	4	813.51	3 12-foot.	81.35	561	9
.80	5	79.36	109.36	24	4	854.16	3 12-foot.	85.41	565	10

[a] Not including well.

CONSTRUCTION OF RESERVOIRS.

If possible a site should be chosen where the natural surface of the ground which will become the bottom of the reservoir is above the land to be irrigated, and if the highest land to be irrigated is some distance from the reservoir the bottom should be enough higher than the land to give a slope of at least 6 feet to the mile from the reservoir to the land.

All sod and vegetation should be removed from the site, as the decay of the roots will leave passage for seepage. In a circle midway between the outside and inside bank line plow a trench 2 feet wide and 1 foot deep, removing this dirt to the outside of the bank; fill in this trench with clay, or with a clay and gravel mixture. After a part of the trench has been so filled add water, and thoroughly puddle so as to form a bond between the original walls of the trench and the material added; haul in additional clay material to this section of the trench until it projects above the original ground surface at least a foot and is yet a soft mass; then proceed to build the banks, puddling and tamping the new fill so as to thoroughly bind with the core of clay material. Proceed with the embankment until the first course to a depth of 6 inches has been completed around the entire inclosure, then add a second course of the same thickness around the entire wall, allowing the teams to walk upon the top of the banks a distance of at least 20 feet each time a scraper is dumped, for in this way each course is well tamped as the work progresses. It would be far better if each course could be thoroughly wet down so as to puddle it or better to tamp the embankment; and even better results would be obtained if the clay core could be carried up with the work to the top of the bank, though this is not an easy matter and is not imperative if the material used in constructing the banks is of a clayey nature. It is well to allow the banks to settle under several rains or snows before the reservoir is filled.

The inside slope of the bank should be very gradual, so as to avoid erosion and cutting. The width of the top of the bank should be not less than 3 feet for a reservoir 4 feet deep, and 4 feet for one 5 feet deep. The slope of the outside of the embankment may be steeper, 1 to 1 if planted to grass, so as to avoid washing or cutting from rains.

Haul into the bottom a lining of clay or clay mixture several inches in excess of the depth of soil removed, and after distributing it evenly pump into the reservoir sufficient water to form a thick muck or paste and thoroughly puddle by keeping cattle or sheep in the reservoir for at least a week, and better for thirty days. Indeed, the entire success of the reservoir is dependent upon such puddling, and there can be no reason why, by placing a temporary fence around the inclosure, the cattle or sheep can not be fed and watered while so penned up for thirty days. It will of course be necessary to allow water to run into the reservoir in small quantities during the operation of puddling, so as to maintain a soft puddle. After the work of puddling is completed the banks may be trimmed to line by shovel.

The inlet and outlet pipe should be put in place while the banks are being constructed, for in this manner a water-tight joint between the pipe and banks can be secured.

Many unique homemade valves or gates have been used, two of which are given in figures 10 and 11. The more permanent and durable the valve the less trouble will be experienced in its operation.

A pipe of about 20-gauge galvanized iron, 6 to 8 inches in diameter and provided with a single low-pressure water-gate valve will be the most reliable. The pipe will permit of a galvanized-iron collar being soldered on where it passes through the bank to prevent the water flowing around and along the pipe, which would tend to cut away the bank. The use of galvanized-iron pipe offers also a ready means of connecting to a distributing pipe outside the reservoir. The use of a gate or square flume may be desirable if the water from the reservoir is to empty into an irrigating ditch, but in this case, as with the iron pipe, a projection should be nailed securely around the flume midway of the bank to prevent washing around the box, and in addition thereto there should be wing boards at the inlet and outlet faces to prevent cutting.

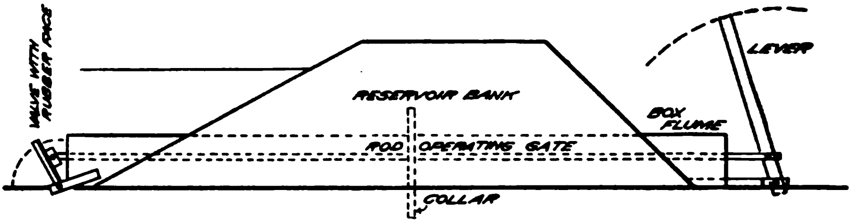

FIG. 10.—Wooden pipe outlet for small reservoir.

A very great economy in the distribution and conveyance of water to the land can be effected by the use of light, riveted, galvanized-iron pipe. These pipes are 6 inches in diameter of 20-gauge iron, riveted and soldered at transverse and longitudinal seams into sections 16 feet long. The ends are made tapering so as to enter easily when slipped together, but become tighter after entering 4 inches. Several elbows 90° and 45° are provided, thus allowing the pipe line to be run in any direction to the point of use. It was found by the use of these pipes at the Cheyenne station that an acre of land situated 500 feet from the reservoir could be irrigated from the reservoir to a depth of 0.25 foot in seven hours when the reservoir head was 2 feet,

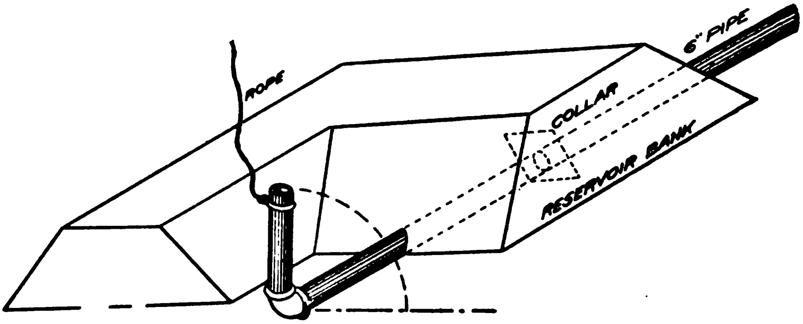

FIG. 11.—Pipe outlet for small reservoir.

and this without the loss of water from seepage and evaporation characteristic of an earth ditch. The cost of such piping is not over $27 per 100 feet, and its life with careful use should be indefinite.

The loss from evaporation in the reservoir can be reduced effectually by the planting of bush willows or some similar low-bush tree profusely around the top of the banks, thereby breaking the wind. The cutting of banks from wave motion can be eliminated entirely in an earthen reservoir by floating a boom of old railroad ties or other timbers around the inner banks facing the direction of the prevailing wind, or if desirable around the entire reservoir. The ties should be held together at the ends by cleats securely nailed and the entire boom should be anchored in a line 3 feet from the banks (fig. 12).

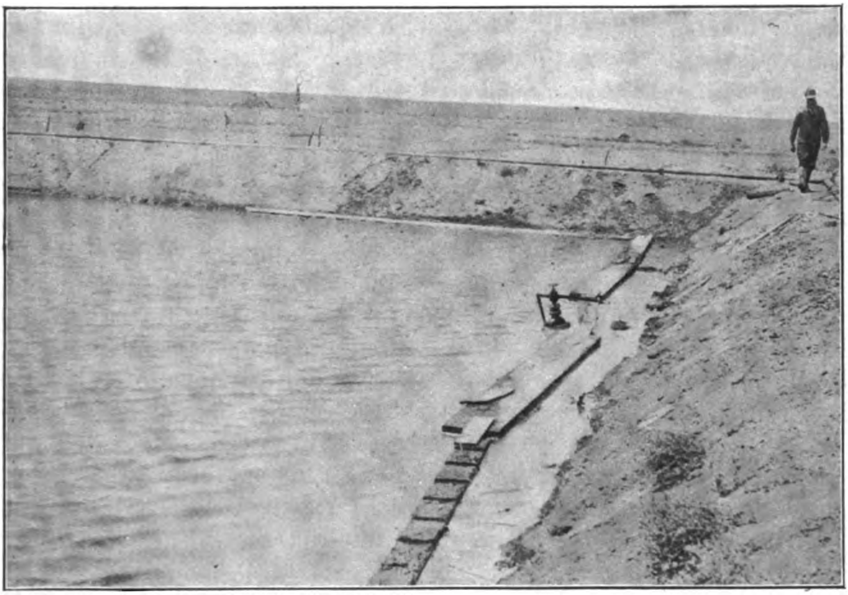

FIG. 12.—Boom to prevent erosion of reservoir banks by wave action.

In previous pages the treatment of reservoirs to reduce seepage or percolation losses was mentioned, and, while this is not essential, if a reservoir is constructed of clay and thoroughly puddled, it is often the case that desirable material is not at hand and it becomes necessary to resort to a method of lining as a substitute for puddling. A bulletin upon this subject by B. A. Etcheverry[a] gives much valuable information upon the subject, so that a discussion of the relative merits of the various linings will not be entered into here, except that a brief account will be given of an experiment at the Cheyenne (Wyo.) station. Here the reservoir was divided into three compartments for the purpose of trying various methods of lining in connection with windmill irrigation. The material of which this reservoir is constructed is a porous sandy soil which seems to resist puddling, as shown by the fact that the average total loss in the large compartment after thoroughly puddling with manure cast over the bottom was 0.35 foot per 24 hours after three months constant use. Nine sacks of cement were cast over the surface of the water with a view to sealing the voids or pores of the soil, but the gain was insignificant and further attempt in this compartment was abandoned, and a treatment of tar was applied to one of the smaller compartments, with a capacity of approximately 0.29 acre-foot. The bottom and banks of this compartment were raked to a mulch 2 inches deep and tar in a boiling state was sprinkled from pails having holes punched in the bottom. The total amount of tar applied was 504 gallons, or 0.121 gallon per square foot, and the cost was about 1.1 cents per square foot for the tar applied. It was found after the reservoir so treated was put into service that the loss was not lessened in the slightest degree and was more than twice that of the large compartment after puddling. A second method of lining with tar was employed in the other small compartment. The banks and bottom were packed and the reservoir was filled and the water allowed to seep away thereby securing a well-packed surface. The reservoir was then allowed to dry out thoroughly and two coats of tar were applied in the same manner as for the other compartment. The quantity applied at the first coating was about 1 gallon per square foot, while the quantity applied at the second coating was approximately 0.06 gallon per square foot. The soil, being packed, did not take up as much tar as the mulched surface did. The reservoir was put into service soon after being treated and the loss was found to be 0.93 foot per 24 hours. However, during constant use for thirty days the loss rapidly decreased until it averaged 0.072 foot per 24 hours. This decrease in the rate of loss was probably due to the fact that the voids were gradually closed by pressure of the water on top and as the tarred particles retained their plastic and adhesive coating they united this coating and the voids became sealed. The fact that when the reservoir was allowed to dry out and then fill again the loss at the start was large, but soon became less, would tend to disprove the above statement, but observation shows that when the soil becomes dry and heated a heaving or movement due to expansion and contraction tends to break up the film which united the sand particles, thereby again opening the voids to percolation. This would be avoided no doubt if the surface could be rolled under heavy pressure, but it is not practicable to so tamp a reservoir. A clay puddle if allowed to dry out cracks so badly that it must be puddled again after each drying.

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[a] California Sta. Bul. 188.

At the station at Eads, Colo., experiments were made with a reservoir of similar proportions, one compartment of which was treated with oil residuum having an asphalt basis, but it was found that the advantage of such a lining was not marked, and after repeated trials the reservoir was finally puddled by stock, and the oil-treated surface was thereby thoroughly mixed with the soil, and a comparatively tight reservoir was secured.

In view of the fact that experiments with various crops were in progress at the Cheyenne station and an assured supply of water was imperative, it was decided to line the large compartment with concrete, and a 3-inch lining was accordingly applied. The rough body was 2 parts coarse sand, 3 parts gravel, and 1 part cement, while a one-fourth-inch dress coat of 1 part sand to 1½ parts cement was placed upon the rough body and left a sand finish as produced by float. Quarter-inch iron rods were used for reenforcement at all corners and angles. The total cost of the lining of this reservoir, having a capacity of 0.8 acre-foot was close to $1,000, and while so great an expense would in many instances be prohibitive to the farmer, the very great saving in water would pay a large rate of interest upon the investment, and it is to be favored in all instances where the expense can be borne. The expense for concrete lining lies very largely in the labor, and with careful attention to the work much, if not all, of it could be done with ordinary unskilled labor, and the expense for lining would thereby be reduced greatly, because it could be done at a time when it would not conflict with the work on the farm. Where a concrete lining is to be applied it is well to drain the reservoir site thoroughly by a system of tile drains, so as to prevent freezing and upheaval of the ground beneath. Also concrete should not be applied to the newly constructed banks, but they should be allowed to settle and pack with water in the reservoir for several months.

MAINTENANCE OF MILLS.

It is unfortunate that the windmill has attained a reputation of not needing attention except at times of breakdown, and conditions are aggravated by the attempts of makers to include automatic oiling devices, which are claimed to be so reliable as to need no attention during an irrigation season. While such devices are commendable in machines operating in places where daily observation is possible, they are out of place in a windmill, which by virtue of its nature must be placed high above the ground, where a special effort must be made if inspection is had, and where it is exposed to the dust and the elements and where the loosening of a bolt may ultimately cause the ruin of the entire engine. Probably from no machine is so much expected for so little attention as from a windmill, and probably no machine will give so much in return for so small an initial investment and so great an amount of energy from nature's store without cost to man. It is a mistake for manufacturers to advertise the simplicity of their particular make of mill and the small amount of attention needed, for in doing so they encourage a still greater neglect and indifference on the part of owners.

It is to be hoped that as the demand for irrigation plants using wind power becomes recognized, manufacturers will strive to build mills of heavy construction scientifically and mechanically built with all working parts machined properly and provided with liberal and positive oiling facilities, and will make vigorous efforts to impress upon the users the similarity between the windmill and any other type of engine with respect to the necessity of thorough oiling and systematic inspection. It is further to be hoped that the purchaser will not be guided in his choice by the cheapness of the product, but by excellence, and it is not amiss to say that very often the cheapest article, whether a mill or a wagon, is in the long run the most expensive.

CROPS UNDER WINDMILL IRRIGATION.

The particular locality of the farm must decide very largely the character of the crops to be raised. If the area under windmill irrigation be increased, it will not be necessary to increase the vegetable garden unless it is desired to engage in truck gardening for a market, but by increasing the grain and forage crop area a larger number of animals can be carried over, or some of the products may be sold. The average value of the crops raised on 2 acres is given, and the returns show conclusively the possibilities of such practice in the cultivation of semiarid lands.

Estimate of crops grown on an ideal windmill irrigation tract, with their values.

Alfalfa, 1 acre, 3 tons, at $10	$30
Potatoes, three-sixteenths acre, 25 sacks, at $1	25
Corn, one-fourth acre, 10 bushels and fodder	10
Pumpkins and melons, one-fourth acre	20
Garden vegetables, one-sixteenth acre	30
Fruit and berries, one-fourth acre	50
Total	165

WINDMILLS IN USE.

What has preceded is in the nature of suggestions made with a view to aiding those who contemplate the installation of a windmill plant, so that installations of a more permanent and reliable character may result, but no greater education can be gained in the conduct of any enterprise than by observation of what has been or is being done by others on similar lines. Data gathered by inspection and observation of many plants now in operation throughout the Western States follow:

WINDMILLS IN WESTERN KANSAS AND NEBRASKA.

An effort has been made to present in the following table the facts of greatest interest, including (1) how much land is irrigated, (2) what is planted on this land, (3) how many trees, (4) what size mills are used, and (5) how large is the reservoir.

For easy reference, each plant is given a number, so that those interested in the details of a plant may follow it through the table without reference to the owner.

Condensed data of windmill irrigation.

GARDEN CITY, KANS.

Number of plant.	Area.	Crops.[a]	Number of trees.	Size of mill.	Cost of plant.	Size of reservoir.	Cost of reservoir.	Annual maintenance.	Value of crops.
	Acres.			*Feet.*		*Feet.*			
1	4.0	G and C	100	10; 12	$200	100 by 30 by 2.	$20	$4.00	$300
2	20.0	G; SB; A	400	25; 10; 10	1,000	100 by 200 by 4.	150	2.50	1,500
3	6.0	G; F; SB	700	12	200	75 by 100 by 5.	20	.50	1,200
4	4.0	A and SB	....	12	200	75 by 100 by 5	20	.50	250
5	25.0	A	800	[b] 3-12	360	90 by 185 by 3.5	100	30.00	1,600
6	8.0	A	....	12	120	150 by 60 by 3.	50	10.00	350
7	8.0	G; SP; C	....	12	150	100 by 3, round	45	3.65	800
8	2.5	G	100	8	55	30 by 100 by 3.	10	4.00	125
9	4.0	G; F; Fl	300	8; 10	85	30 by 35 by 3.5	15	2.00	200
10	3.0	G	100	10	102	20 by 70 by 2..	15	1.50	500
11	2.0	G; F	40	10	75	30 by 50 by 2..	12	....	150
12	8.0	G; F	800	8; 12	185	85 by 110 by 3..	40	11.00	550
13	5.0	B; F; G	125	10	100	50 by 100 by 2.5	20	2.00	500
14	1.5	B; F; G	200	8	92	24 by 24 by 2..	10	.75	400
15	2.5	G	100	8; 10	70	30 by 30 by 3..	10	....	300
16	2.0	G and F	800	14	175	75 by 75 by 3.5	25	5.00	....
17	7.0	G and SB	150	2-12	230	125 by 125 by 3.	40	30.00	200
18	2.0	G	146	8	70	40 by 40 by 2.5	15	.50	150
19	1.0	G	200	8	12	35 by 35 by 2..	10	3.00	200
20	5.0	B; F; G	800	2-8	150	50 by 50 by 2.5	50	1.50	300
21	4.0	G and F	3,000	12	103	75 by 75 by 2.5	15	.50	500
22	4.0	SP	....	10	93	30 by 70 by 3..	15	.50	250
23	.25	C	30	8	62	50 by 50 by 3..	25	.50	100
24	3.0	G and F	300	10	91	25 by 25 by 2..	10	1.50	500
25	10.0	G; A; F	1,000	10; 12	230	100 by 110 by 3.	30	1.50	750
26	3.0	B; F; G	260	8; 8	90	30 by 50 by 3..	13	1.35	500
27	4.0	G and F	375	12	128	50 by 30 by 3..	12	15.00	500
28	12.0	G and F	500	2-12	225	100 by 500 by 3	50	....	500
29	10.0	G and F	150	2-12	193	75 by 100 by 2.5	15	....	1,500
30	5.0	B; F; G	100	12	72	60 by 60 by 4..	20	5.00	200
31	2.5	B; F; G	100	2-8	164	40 by 50 by 2..	10	.75	200
32	2.5	B; F; G	75	8	60	60 by 60 by 3..	20	5.00	200
33	4.0	G	....	12	85	2.5 by 50 diam.	40	7.00	200
34	4.0	G	300	12; 8; 8	250	100 by 100 by 3.	50	12.00	300
35	2.0	G	800	8	75	20 by 25 by 2..	10	None	100
36	10.0	T	2,000	2-12	200	250 by 100 by 3.	75	....	700
37	2.5	G	150	10	75	20 by 111 by 2.5	10	5.00	175

INGLES, KANS.

38	7.0	G and A	230	16; 10	$225	100 by 150 by 2.	$50	$10.00	$175

[a] The following abbreviations are used: A, alfalfa; B, berries; C, cantaloups; F, fruit; Fl., flowers; G, garden; SB, sugar beets; SP, sweet potatoes; St, strawberries; T, trees.

[b] This indicates three 12-foot mills. Other similar figures indicate number of mills of the size given.

Condensed data of windmill irrigation—Continued.

Number of plant.	Area.	Crops.[a]	Number of trees.	Size of mill.	Cost of plant.	Size of reservoir.	Cost of reservoir.	Annual maintenance.	Value of crops.
CIMARRON, KANS.									
	Acres.			*Feet*		*Feet.*			
39	3.0	F; A; G	1,000	[illegible]	$200	75 by 75 by 2	$20	$10.00	$200
40	2.0	G	150	16	105	20 by 33 by 3	25	3.00	90
41	1.0	G	75	10	92	30 by 50 by 3	6	4.00	100
DODGE CITY, KANS.									
42	2.0	G	300	8	$92	30 by 30 by 3.5	....	$0.50	$200
43	.5	G	150	6	46	2 by 25 diam	....	....	75
44	5.5	G	170	10; 12	215	110 by 200 by 2	$50	20.00	1,000
45	3.0	G and F	900	10; 8	200	110 by 200 by 2.	20	....	200
46	1.0	B; F; G	90	6	65	25 by 45 by 3	15	50.00	200
47	4.0	F; A; G	900	12	400	9 by 16 diam	100	1.35	200
48	.5	T (orchard)	1,804	10	60	42 by 67 by 2	....	....	....
49	2.0	B; F; G	150	6; 8	125	90 by 100 by 2.	20	.50	500
KINSLEY, KANS.									
50	4.0	G and F	500	12	$400	5 by 50 diam	$25	....	....
51	.5	SP and G	....	8	58	30 by 55 by 5	15	$1.50	$75
52	.25	G and T	2,000	8	60	Standpipe	....	.50	600
53	2.0	G and F	100	12	171	64 by 190 by 2.	60	2.00	400
54	2.0	G	....	12	122	38 by 115 by 2.	30	2.00	400
55	5.0	B and G	100	12	172	40 by 60 by 4	100	25.00	1,000
GREAT BEND, KANS.									
56	.5	B and G	200	10	$125	....	....	$0.75	$100
57	1.0	B and G	....	6	61	5 by 5 diam	$24	.50	200
58	5.0	B and A	50	12	75	110 by 150 by 2.	500	5.00	800
HUTCHINSON, KANS.									
59	2.5	B and G	....	8	....	8.5 by 7.5 diam	....	....	....
60	4.0	St	....	12	$270	....	....	$0.50	$800
HUTCHINSON, NEBR.									
61	[illegible]	G	10	8	$83	....	....	$0.50	$100
62	1.0	G	300	8	55	6 by 5 diam	$175	3.00	75
63	4.5	G and A	60	8	75	....	....	....	125
64	6.0	G and F	300	10	135	66 by 65 by 3	100	.50	600
65	1.3	G	25	6	90	6 by 5 diam	100	.50	50
66	14.0	A and G	....	12	125	....	....	1.00	1,000
67	10.0	G	850	16	250	100 by 200 by 2.	100	3.00	600
68	10.0	A	25	2	....	100 by 200 by 5.	....	....	....
69	10.0	G	225	[b]3-8; 12; 14	....	200 by 100 by 3.	100	....	600

[a] The following abbreviations are used: A, alfalfa; B, berries; C, cantaloups; F. fruit; Fl, flowers; G, garden; SB. sugar beets; SP, sweet potatoes; St, strawberries; T, trees.

[b] The three 8-foot mills not now in use.

While in some instances the gross returns for crops from these small areas are not so high as to present an attractive commercial aspect, it should be borne in mind that the main purpose of this bulletin is not to show the advantage of truck gardening or horticulture as a commercial enterprise, though the possibilities in this field are very great, but to encourage the cultivation of small areas of irrigated land in connection with the farming without irrigation of large areas of land which must necessarily fail to produce crops during seasons of scanty rainfall. However valuable may be the results obtained by cultivation after rainfall or summer fallow of land whereby a part of two years' moisture may be conserved to be used in one year's cropping, it must be conceded that a lack of moisture in natural precipitation can not be compensated for by any method of tillage of soil, and loss must necessarily ensue during the years of drought. During past years, many an ambitious farmer has taken up land under arid conditions and after several years of deprivation and toil has been compelled to abandon his homestead, not infrequently being compelled to dispose of his household effects in order to acquire means to defray the expense of travel. Not many years have elapsed since entire towns, built during years of plentiful rainfall, have been abandoned because of several years of meager precipitation, only to be resurrected during a recurrence of a succession of wet years. One instance is recorded where in five years more wheat has been sown on a section of land under dry-farming practice than has been harvested. In this instance, the owner had prospered in cattle raising; but, being aroused to enthusiasm by the great claims for new systems of dry farming, he was induced to dispose of his cattle to realize greater returns from his land, with the result stated. How different would be the conditions if 5 or 10 acres of each homestead were planted to the crops necessary to domestic need and to the feeding of the few head of stock required in the conduct of farm operations, and this small area were irrigated by windmills. In times of limited precipitation, when cropping of the large area is not feasible, abandonment of the entire homestead will not be necessary.

WINDMILLS IN EASTERN COLORADO.

Eastern Colorado represents a region which was principally a dry-farmed district formerly, but which, during years of scanty precipitation, was practically abandoned because of the inability of the farmers to secure a livelihood from the land without irrigation.

The use of windmills in this section of the West was not primarily for irrigation, but for stock water, though it was soon found that, during the time when they were not needed for such purposes, they could be employed in the irrigation of a few trees or perhaps a small garden plat; but this secondary use of the windmill was discontinued as the stock-water demand increased, and this condition continued until the price of cattle became so low as to discourage the small stock raiser, when he turned again to the tillage of the soil. It was then that the great possibilities of irrigation from windmills in that district became known and exploited. A marked contrast exists between the farmers dependent upon the raising of stock alone or the cultivation of dry-farm areas without irrigation, and those who have converted a small part of their land into windmill-irrigated plats in this part of Colorado. It is a noteworthy fact that the use of the windmill is confined to districts where the success of one plant has been a stimulus to others. Where the initial plant has been a failure, owing possibly to improper loading of the mill or to excessive head, those who might otherwise have been successful have not been inclined to investigate the cause of failure, and so continue in indifferent success, always with the possibility of a complete failure during years of insufficient rainfall. It is of interest also to note that those plants which are successful are owned by men who were compelled by circumstances to count the cost of every expenditure and to do those things themselves which others might have hired done. These men, too, have practiced the greatest economy in the use and application of water to the land and have increased the irrigated area from a few rods to perhaps several acres, or as fast as their experience taught them it could be increased with the original supply, or by increasing the capacity within their means.

The average depth of water applied to the land in this part of the West is about 6 inches, which, in addition to the average rainfall, makes 16 inches during the growing season; and while some years the trees require no water other than the natural rainfall, the succulent vegetables receive water whenever it is needed. With proper soil cultivation a considerable amount of moisture may be conserved from the winter snows, though this depends on the character of the soil, its depth, character of subsoil, and the extent to which cultivation is carried on.

The investigation of windmill-irrigated plats in eastern Colorado included dry farms of 20 to 200 acres. The total record includes 2,320 acres dry-farmed, upon which the average gross annual return per acre was $6.50. The average cost of production was between $2 and $3 per year. The average cost of 8, 10, 12, 14, and 16 foot mills, together with the average area irrigated, is given in the table following. It will be noted that the areas irrigated are far smaller than recommended and smaller than are being irrigated in parts of Kansas and Nebraska. The primary reason for this is that the lift is much greater than in Kansas and Nebraska.

Average cost of mills of different sizes, and areas served in Colorado.

Number of mills.	Size of mills.	Average cost.	Average area.
	Foot.		*Acres.*
18	8	$102	0.7
12	10	198	1.8
9	12	195	2.4
8	14	265	3.8
2	16	188	3.6

The following is a tabulated statement of plants investigated. It was difficult to ascertain exact cost, owing to the fact that much of the work of installation and construction was done by the owners themselves, and no record of the time employed was kept. The original cost of the plant includes only the cash outlay in most instances.

Data relating to windmill irrigation in eastern Colorado.

Number of plant.	Area irrigated.	Crops.[a]	Value of crops.	Area dry-farmed.	Size of mill.	Lift.	Size of cylinder.	Reservoir.		Cost of plant.	Cost of maintenance.	Value of plant.
								Size.	Capacity.			
	Acres.			*Acres.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Cu. ft.*			
1	0.25	G	$50	150	10	115	2.0	75 by 16 by 9	10,800	$1,200	$5.00	$1,500
2	1.00	G and T	100	25	10	45	3.0	......	248	175	2.50	500
3	½	G	100	4	10	14	3.0	......	3,000	225	5.00	500
4	2.00	G	100	......	10	11	4.0	......	200,000	250	5.00	1,000
5	1.50	G, F, T	200	......	10	84	4.0	40 by 60 by 6	14,400	300	6.00	500
6	.50	G	100	20	8	33	3.0	40 by 50 by 4	8,000	150	10.00	300
7	.75	G and T	150	70	10	71	3.0	28 by 14 by 2	784	175	5.00	1,000
8	1.00	G and F	100	40	8	64	2.5	22 by 12 by 3	792	75	10.00	500
9	3.00	G, SB, T	248	......	10	17	4.0	150 by 60 by 2	18,000	175	8.00	500
10	2.00	G and F	125	105	12	65	4.0	150 by 50 by 3.5	15.750	200	9.00	500
11	4.00	G and F	200	225	16	62	5.0	100 diameter	31,416	175	20.00	1,000
12	4.00	G and F	200	225	14	......	......		......	150	18.00	
13	5.00	G and F	200	100	14	74	5.0	......	84,000	400	20.00	1,000
14					12	62	4.0			230	25.00	
15	8.00	No returns			15	54	3.5	130 by 130 by 4	171,600	300	18.00	400
16	16.00	A, F, and G	540	200	8	15	5.0	60 by 60 by 6	21,600	400	4.00	2,500
17					8	20	4.0					
18					8	20	4.0					
19					8	15	5.0	40 by 60 by 2	4,800			
20	1.50	G and F	150	130	9	11	4.0	60 diameter	8,160	150	3.00	500
21					8	15	4.0					
22	2.00	G and F	200	150	12	115	2.5	30 diameter	2,600	400	15.00	1,000
23					10	115	2.5	......	1,760			
24	1.00	G and F	200	None.	8	5	2.5	(b)	......	80	10.00	1,000
25	1.00	G and F	75	130	8	20	4.0	(b)	......	100	5.00	1,000
26	1.00	G and F	200	70	8	23	4.0	......	4,542	100	5.00	1,000
27	2.00	V and F	300	30	8	18	2.5	(b)	......	100	7.00	1,500
28					8	19	4.0	......	19,250	150	8.00	
29					8	18	2.5	(b)	......	50	5.00	
30	2.00	G and F	200	60	8	14	4.0	......	8,100	200	8.00	1,000
31	2.00	G and F	200	70	8	14	3.0	......	8,000	100	6.00	1,000
32					8	14	4.0	......	21,000	100	6.00	
33	.25	G and F	100	75	8	65	2.0	......	216	100	10.00	300
34	5.00	G and F	300	40	16	18	6.0	16 by 16 by 2	512	200	15.00	1,000
35	1.00	G and F	100	130	12	......	......	25 by 60 by 3	4,500	150	10.00	500
36	4.00	G, F, T	100	100	14	81	......	53 by 63 by 5.5	18,000	365	15.00	5,000
37	13.50	St., G, F	560	70	14	65	4.0	120 by 60 by 4.	28,800	225	10.00	2,000
38					14	66	4.0	90 by 90 by 4	32,400	225	10.00	
39					14	72	4.0	60 by 60 by 3.5	12,600	225	10.00	
40	.50	G and F	150	160	12	120	2.5	20 by 60 by 2.5	3,000	275	15.00	......
41	1.50	G and F	150	10	10	125	2.5	......	378	275	5.00	1,000
42	2.00	G and P	150	100	14	220	3.0	......	1,353	305	15.00	1,000
43	.50	G and T	100	75	10	12	3.0	......	......	175	6.00	200
44					8	20	2.5	......	......		4.00	
45	12.00	G and P	575	None.	14	14	5 and 4	80 by 110 by 4.	35.200	400	15.00	2,000
46					12	14	4.0					
47	8.50	G and SB	480	None.	12	18	5.0	50 by 110 by 2.	11,000	190	6.00	1,000
48					10	15	4.0	50 by 50 by 2.5	3,750	160	4.00	
49	1.00	G and F	100	30	12	14	3.5	(b)	......	100	......	300
50	10.00	G and P	500	None.	10	40	4.0	(b)	......	135	......	1,000
51					10	40	4.0	16 by 32 by 2.5	1,280	150	......	
52					12	45	6.0	75 by 75 by 4	22,500	215	......	

[a] A, alfalfa; F, fruit; G, garden; SB, sugar beets; St, strawberries; T, trees.
[b] No reservoir.

WINDMILLS NEAR STOCKTON, CAL.

The windmill universally used for irrigation purposes in the vicinity of Stockton, Cal., is a wooden wheel 22 feet in diameter, bolted to a

2-inch crank shaft, which has a direct stroke of 12 inches. The bearings of the shaft are made of hard maple and mounted on a turntable on the top of a 40-foot wooden tower. The wheel has to be turned into the wind by means of a pole fastened to the turntable, operated by two ropes, as shown in figure 13. The mill is connected by a driving pole to a walking beam about 12 feet long, at either end of which is fastened the driving rod of an 8-inch cylinder pump, as shown in figure 14. The connection of the main driving pole to the walking beam is a ball and socket joint and is shown clearly in figure 14. This tandem mill will raise about 300,000 gallons of water per day under favorable conditions. The illustration gives the dimensions used ordinarily. The pumps are of the cylinder-suction type, with two valves, the prevailing sizes being 8 and 9 inches. There are two types used. The plunger with its metal valve is the same in both kinds, but the lower valves differ. One is the regular hinged valve cut out of rubber packing with a weight fastened to the top of the hinged portion to keep it closed on the downstroke of the plunger (fig. 15). The other type has a metal lower valve similar to the valve in the plunger.

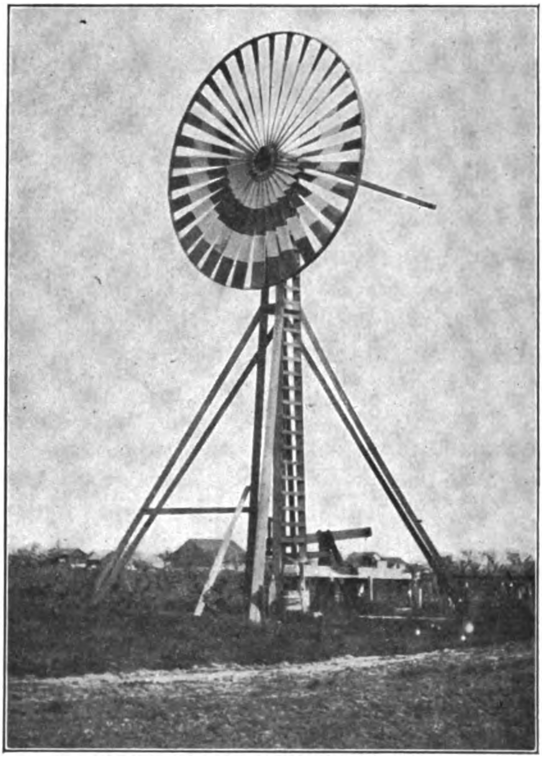

FIG. 13.—Wheel turned into the wind and held there by means of ropes.

Most of the wells in this section are bored in order to get below the surface water and avoid the alkali, for the water table lies about 15 feet below the ground line. The wells are cased at the time they are bored, and often reach to a depth of over 100 feet. Then the water rises to within 10 or 15 feet of the surface of the ground. The well is bored down to a stratum of sand and then the sand is pumped out, forming an underground reservoir.

The wooden mill has outclassed the steel mill in this vicinity, both in maintenance and length of satisfactory usefulness. Some of the old wooden mills in Stockton have been running for thirty years.

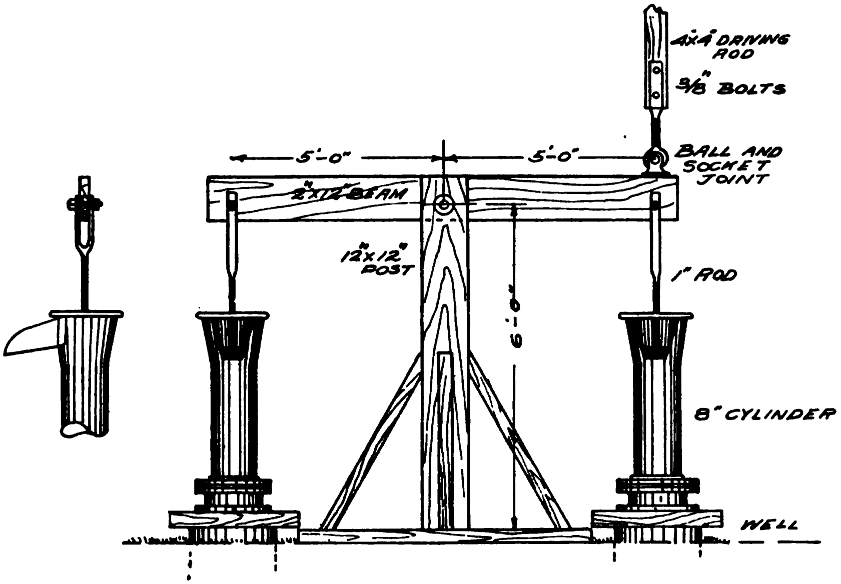

FIG. 14.—Manner of connecting driving rod of windmill to pumps used near Stockton, Cal.

It would be hard to say the same for the steel mills. Windmills are so placed as to irrigate the land most efficiently and are often such a distance from the house that it is inconvenient to oil them frequently or give them the proper care. For this reason the wooden mills have the advantage. The steel mills have metal bearings, which must be oiled very often during the season when most in use or they will heat and the friction will soon cut them out. The wooden mills have hard maple bearings which need a thorough oiling once a week until they are saturated, then once a month is sufficient. In case the wooden bearings do run dry no harm will result, while the bearings of the steel mills would be ruined, and the parts are not replaced conveniently.

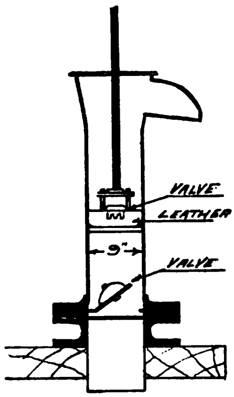

FIG. 15.—Type of pump used near Stockton, Cal.

Throughout this section the farmers having large areas to irrigate are using electric motors and gasoline engines with the centrifugal pumps, as they can be depended upon always, while the wind is uncertain as a motive power. No provision was made for storage of water in this section, as it seemed so plentiful. Undoubtedly if large reservoirs were added to the windmill plants in this district the use of motors and gasoline engines would not be required, for there are few places where water may be secured in so large quantities at such shallow depths.

No attention has been given in this bulletin to the subject of home-made mills for irrigation, for the reason that while it is possible to construct a mill of some type where one has the tools and time necessary, as a rule the result is not satisfactory and the small returns from such a mill will tend to discredit the possibilities of windmill irrigation with a modern factory-built mill. No mills of the types known as Jumbo, Battle Ax, or Merry-go-round are included, for reasons stated above. The results of investigations show them to be low in efficiency and unsuited to the ends of a modern irrigation mill. Even the modern mill is far from perfect, but it is the effort of the manufacturers to better the product as use demonstrates its weaknesses.

The object of this bulletin is to give some practical suggestions to those who are now using or are contemplating the use of windmills for pumping water for irrigation. Windmills are used quite extensively for this purpose already, and there is a wide field for extending their use. The data given for plants on the Great Plains show, however, that the windmill is not a cheap source of power, and that it will not, as is so often claimed, run without attention. A windmill should be looked after as carefully as any other piece of machinery, and if this is done it will provide power for the irrigation of considerable areas at an expense which will be justified by the crops grown.

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Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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Issued May 5, 1910.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 395.

SIXTY-DAY AND KHERSON OATS.

BY

C. W. WARBURTON,

Agronomist in Charge of Oat Investigations,
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1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 23, 1910.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Sixty-Day and Kherson Oats," prepared by Mr. C. W. Warburton, Agronomist in Charge of Oat Investigations.

The value of early oats in the corn belt and in the Great Plains region, particularly in unfavorable seasons, has been fully demonstrated. Two varieties from southern Russia, one of which was introduced by this Department, have come into special prominence in this connection. The experience of a number of farmers, experiment-station workers, and others with these varieties is reviewed herein. The results shown should materially increase the popularity of early oats on corn-belt and dry-land farms.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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SIXTY-DAY AND KHERSON OATS.

INTRODUCTION.

Practically four-fifths of the oat crop of the United States is produced in the thirteen States extending from New York and Pennsylvania westward to North Dakota, South Dakota, Nebraska, and Kansas. Each of these States annually devotes more than a million acres to oats. The average yield in the six northernmost States, New York, Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota, is 31.68 bushels to the acre, while their total production is slightly less than one-third of the oat crop of this country. The average yield of the other seven States, Pennsylvania, Ohio, Indiana, Illinois, Iowa, Nebraska, and Kansas, is only 29.23 bushels to the acre, yet they produce more than half of the entire crop. The difference in yield of nearly two and one-half bushels to the acre between these two groups of States is due largely to the fact that the climatic conditions of the northern group are better suited to the production of the crop. There is no material difference in soil preparation or other influencing factors.

Oats are grown in the corn belt, which includes all the States of the second group, largely because a small-grain crop is needed in the rotation and because the grain is desired for feeding to work stock. Spring wheat is seldom satisfactory in this district, and winter crops often do not fit well into a rotation which ordinarily includes corn, a small grain, and grass. Under these conditions oats are generally grown as the best crop between corn and grass. This is particularly true in Illinois and Iowa, the two States producing the greatest quantity of both corn and oats.

THE NEED FOR EARLY OATS.

There are several factors which reduce the yield of oats in the corn belt. Poor preparation of the soil, unfavorable weather conditions, injury from rust and lodging, and the use of unsuitable varieties are among the most potent influences. All these deterrents, except poor preparation, may in a measure be overcome by the sowing of varieties better suited to the conditions of the section where they are grown. In general, those best adapted to the corn belt are those which mature earliest, for early maturity often enables a crop to escape the hot weather, injury from storms, and the attacks of plant diseases. The early varieties also usually produce less straw, and for that reason are less likely to lodge than the ranker growing late varieties. A number of years ago the Early Champion and the Fourth of July varieties came into prominence, but they are not now extensively grown, for, although early in maturing, their yield is often unsatisfactory. Burt is a very early variety much used for spring seeding south of the Ohio River but little known elsewhere. The type of early oats now most largely grown in this country is represented by the Sixty-Day and the Kherson varieties, two comparatively recent introductions from Europe. Their adaptation to our conditions is discussed in this bulletin.

HISTORY OF KHERSON AND SIXTY-DAY OATS.

Most of the varieties of oats now grown in the northern half of the United States came originally from northern Europe or have been produced from varieties from that section. Our great central valleys are, however, subject to high summer temperatures not found in the more equable climate of northern Europe, and for that reason the varieties of oats from Germany, Sweden, and similar European sources have not been altogether satisfactory in our corn belt. Conditions more nearly approaching our fertile prairie sections are found in the chernozëm or "black-earth" district of southern Russia. This district is one of wide extremes of heat and cold, with rather low rainfall. The hot summer and rich soil make it comparable with the corn belt, and though the rainfall is lower it is readily seen that varieties of grain of value there are likely to prove desirable over a large portion of the United States.

The Nebraska Agricultural Experiment Station[a] secured seed of an early variety of oats from this section in 1896 through Prof. F. W. Taylor, then superintendent of farmers' institutes in Nebraska, who obtained it in the course of a journey through Russia. This seed was sent out under the name Kherson, that of the district from which it came. It was quite widely distributed in Nebraska, but for several years was little known outside that State. In March, 1901, an importation of a similar variety was received by the United States Department of Agriculture from Mr. C. I. Mrozinski, of Proskurov, in the Podolia government of Russia.[b] This province lies just west of the Kherson government and its climatic and soil conditions are much the same. This variety was received as "Sixty-Day" and has been widely distributed under this name. It closely resembles the Kherson and is practically identical with it, although under the same conditions there is sometimes considerable variation in yield.

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[a] Bulletin 84, Nebraska Agricultural Experiment Station.

[b] Bulletin 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, S. P. I. No. 5938.

DESCRIPTION OF KHERSON AND SIXTY-DAY OATS.

The two varieties Sixty-Day and Kherson are so similar in appearance that the same description may be applied to both. The plant is a vigorous but not rank grower, usually less inclined to lodge than varieties with coarser straw. The head, or panicle, is loose and spreading, bearing a large number of grains. The grain is small to medium in size, long, and rather slender, but, under favorable conditions, plump and well filled. Heads of Sixty-Day oats are shown in figure 1, while figure 2 shows heads of this and of two other varieties imported by the United States Department of Agriculture. The color of the Sixty-Day and the Kherson oats varies with the locality. In the corn belt the grain is a deep golden yellow, while farther north and in drier sections it is much paler, becoming almost white in the extreme West and Northwest. The hull is very thin and the weight per bushel usually high. The crop ordinarily reaches maturity in 90 to 100 days, or about 10 days earlier than most of the varieties commonly grown.

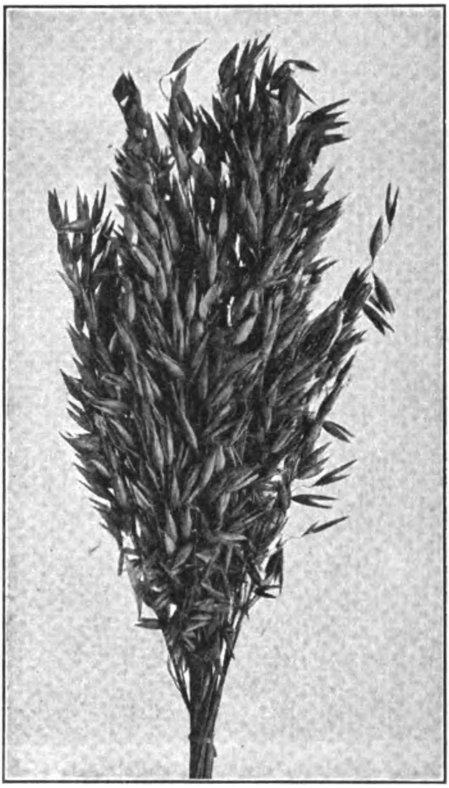

FIG. 1.—Heads of Sixty-Day oats.

DESIRABLE AND UNDESIRABLE CHARACTERS.

The principal objections urged by farmers against this class of oats are the yellow color and the small size of the berry. In some markets there is a discrimination in favor of white oats of 1 or 2 cents a bushel, but by far the larger portion of our oat crop is fed on the farms where produced, and yellow oats are just as good for feeding as those of any other color. On the other hand, on account of its thin hull this particular type of oats is higher in feeding value than are most other varieties. In tests made some years ago by the writer in which samples of a number of varieties from Wisconsin, North Dakota, Kansas, and Montana were examined, the Kherson and the Sixty-Day oats ranked highest in the proportion of kernel to whole grain in every case. The highest percentage recorded was 78.07, from a sample of Kherson grown in Wisconsin in 1905, while the lowest was 54.86, from a sample of white oats grown in the same State the following year. Kherson and Sixty-Day oats grown under exactly the same conditions as this latter sample showed more than 70 per cent of kernel. The average of 12 samples of these two varieties showed 73.3 per cent of kernel, while 39 samples of other varieties showed 69.2 per cent. On this basis, where ordinary oats are worth 50 cents a bushel for feeding, the Sixty-Day and the Kherson are worth 53 cents. Frequently the difference in favor of the latter varieties is even greater. The North Dakota Agricultural Experiment Station says that on account of its thin hull the Sixty-Day is worth 4 or 5 cents more a bushel for feeding than some other varieties.[a] A comparison of the grain of Sixty-Day and that of

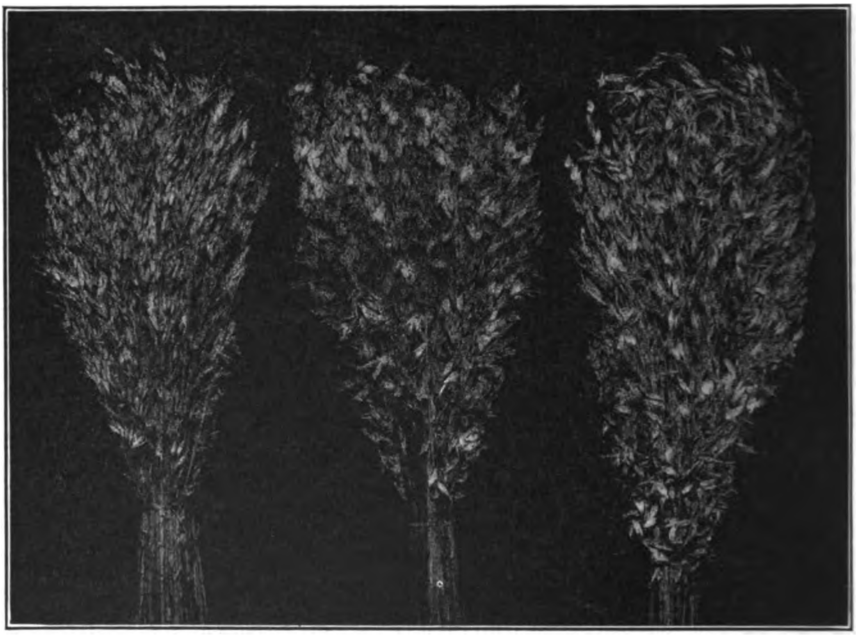

FIG. 2.—Heads of three varieties of oats imported by the United States Department of Agriculture, the Sixty-Day on the left, the Swedish Select in the center, and the North Finnish Black on the right.

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[a] Bulletin 79, North Dakota Agricultural Experiment Station, p. 481.

Swedish Select, a medium-late, large-grained oat now very popular in the Northern States, is shown in figure 3. The weight of 1,000 grains of this sample of Swedish Select was nearly one and one-half times that of the same number of grains of the Sixty-Day sample, but the proportion of kernel to hull was considerably larger in the latter.

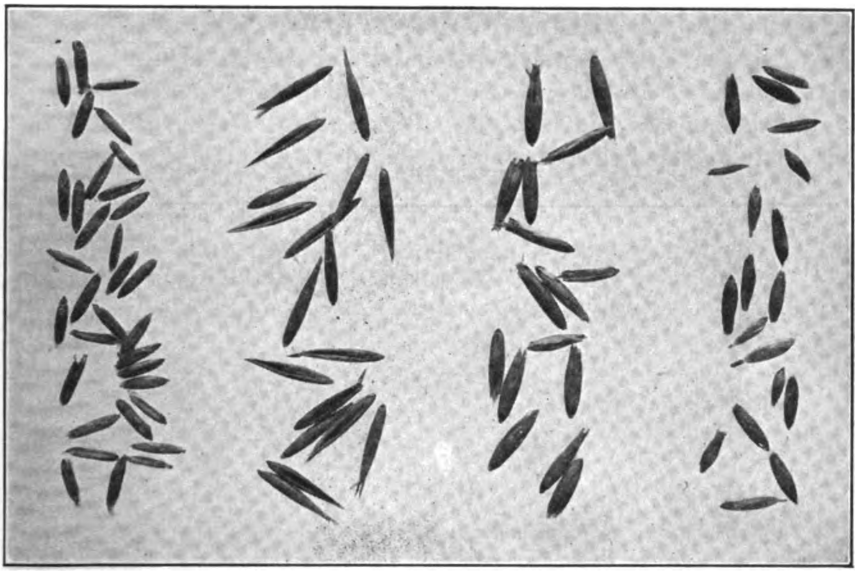

FIG. 3.—Grains of the Sixty-Day (left half) and the Swedish Select oats (right half) with and without hulls. The sample of Sixty-Day contains 73.5 per cent of kernel, while that of Swedish Select contains but 69 per cent.

The following table shows the chemical composition of the Sixty-Day oats as compared with the Swedish Select, the North Finnish Black, the Burt, the Rustproof, and 72 miscellaneous samples.

TABLE I.—*Results of analyses of oat varieties, showing percentage of water and the number of pounds of ash, protein, etc., in 100 pounds of water-free substance.*[a]

Variety.	Number of samples analyzed.	Per cent of water.	Pounds in 100 pounds of dry matter.				
			Ash.	Protein.	Fat.	Crude fiber.	Carbohydrates.
Sixty-Day	39	8.90	3.94	14.69	3.89	11.00	66.55
Swedish Select	128	7.10	3.90	12.85	4.00	12.23	66.99
North Finnish Black	12	8.76	4.00	12.10	4.89	13.32	65.67
Burt	7	8.56	4.37	14.34	6.21	11.41	63.67
Rustproof	8	7.74	3.75	13.32	4.61	11.60	65.72
Miscellaneous	72	9.96	3.72	13.40	4.91	13.24	64.73

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[a] Bulletin 120, Bureau of Chemistry, U. S. Dept. of Agriculture. The 72 miscellaneous samples were grown in the United States and Canada and were analyzed at the World's Columbian Exposition in Chicago in 1893.

The feeding value of the Sixty-Day oat is well shown in this table. The chemical analyses bear out the statements previously made regarding the small proportion of hull. The high protein content and the small amount of crude fiber are especially worthy of note.

In some sections the Kherson and the Sixty-Day oats mature at the same time as winter wheat, and for that reason are not popular, though by some the fact that they can be harvested and thrashed at the same time as wheat is considered an advantage. This early thrashing enables the grower to market his oats ahead of the main crop, sometimes at much better prices than can be obtained later. In the spring-wheat district or where large acreages of oats are grown, they extend the length of the harvest season.

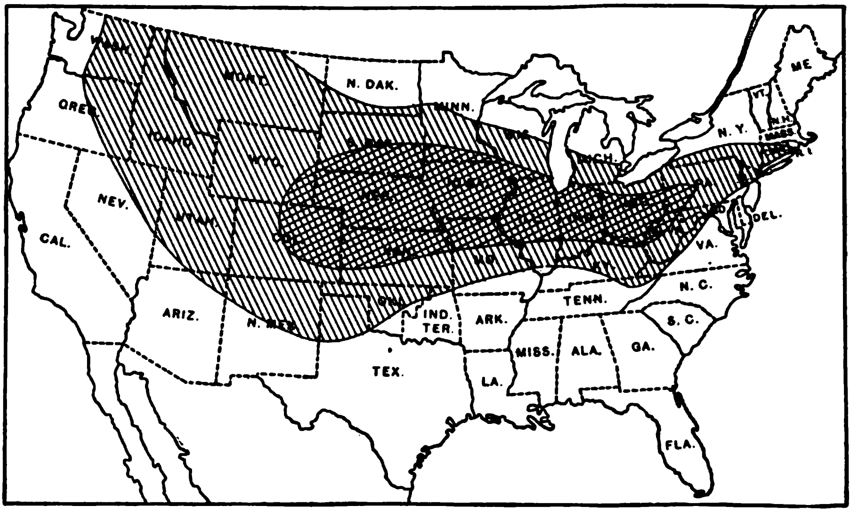

FIG. 4.—Map of the United States, the shaded portion showing the area to which the Sixty-Day and the Kherson oats are adapted. The heavily shaded portion shows the region where the best results are likely to be obtained with these varieties.

On account of their short straw and early maturity they are among the best varieties for use as nurse crops. Their yield of straw is less than that of most other varieties, so that where a large quantity of roughage is desired this type of oats is not to be recommended. The straw is of excellent quality, however, and is readily eaten by stock.

Less seed can be used than of the large-grained varieties. Seeding at the rate of 2 bushels to the acre is sufficient where 2½ bushels is the ordinary rate.

ADAPTABILITY TO VARIOUS SECTIONS.

While neither the Kherson nor the Sixty-Day oat has yet been tested over the entire oat-growing area, they have been distributed widely enough to give a good idea of their adaptability. They probably have a wider range than any other variety. The States where best results may be expected include those of greatest acreage—Pennsylvania, Ohio, Indiana, Illinois, Iowa, Nebraska, northern Kansas and Missouri, southern Wisconsin and Minnesota, South Dakota, and eastern North Dakota. They are particularly to be recommended in Illinois, Iowa, and Nebraska. Indiana reports have been rather unfavorable. Good returns have been obtained under dry-farming conditions in Montana, Wyoming, Colorado, New Mexico, Utah, Idaho, Washington, and Oregon. Where water for irrigation is available some of the larger grained later varieties will usually give heavier yields. This is also true in the northern tier of States, where conditions are more favorable to the late varieties than they are farther south.

The accompanying map (fig. 4) shows approximately the sections to which the Sixty-Day and the Kherson oats are adapted. The heavily shaded area shows the district in which these varieties are likely to prove most successful and, in a general way, where they will largely replace other varieties.

RESULTS OBTAINED BY EXPERIMENTERS.

The statements which follow have been compiled from the bulletins of the various state agricultural experiment stations, unpublished correspondence and reports from these stations, the reports of cooperative and other stations maintained wholly or in part by the Bureau of Plant Industry of the United States Department of Agriculture, correspondence with seed dealers, and the reports of farmer cooperators.

TESTS IN THE EASTERN STATES.

Maryland.—Few tests of the Sixty-Day and the Kherson oats have been made in the Eastern States. Soon after its introduction Sixty-Day was grown for two or three years at the Maryland station, where it gave as good yields as Burt and Rustproof. As winter oats usually give much better returns than spring varieties at this station, the growing of the latter was discontinued about 1905. From the results secured previous to this time it would appear that Sixty-Day is as well adapted to spring seeding in Maryland as are Burt and Rustproof.

Pennsylvania.—Prof. F. D. Gardner, of the Pennsylvania station, reports that the Sixty-Day was the highest yielding oat in a three-year test, from 1907 to 1909, in which twenty-three varieties were included. The average yield was 58.9 bushels to the acre, only slightly higher than that of Joanette, Big Four, Japan, and Lincoln, which ranked in the order given. The average weight per bushel of Sixty-Day was 32.1 pounds, and the average yield of straw, 2,252 pounds to the acre. The average yield of all the varieties for the three years was 54.9 bushels of grain and 2,662 pounds of straw. Sixty-Day ripened 8 or 10 days earlier than most of the other varieties, but is objectionable on account of its low yield of straw and its appearance. Kherson has been tested but one year, 1909, when it gave the highest yield of the twenty-four varieties tested—63.6 bushels.

New York.—Neither of the varieties under discussion has been included in the field tests at the New York (Cornell) station, but a number of Sixty-Day selections have been included in the plant-nursery work, where they have made an excellent showing. In general, however, conditions in New York are more favorable to the growth of the larger later varieties than to those of the Sixty-Day type.

TESTS IN THE NORTH-CENTRAL STATES.

Ohio.—At the Ohio station the Sixty-Day oat ranks second among the fifty or sixty varieties under test, with an average yield of 69.75 bushels to the acre for the six years from 1904 to 1909. For the same period Siberian averages nearly 1 bushel to the acre more, while the yield of Improved American almost equals that of Sixty-Day. The weight per bushel of Sixty-Day and of Improved American is practically the same, about 26.25 pounds, while Siberian is nearly 1.5 pounds heavier, averaging 27.67 pounds. Kherson has not been tested at this station. Prof. C. G. Williams, the agronomist, writes that Sixty-Day is the earliest oat under test there, and in unfavorable seasons, such as have recently occurred, it matures, to some extent at least, ahead of the plant diseases which severely injure some of the later varieties. His greatest objection to the variety is its rather weak straw[a] which, he says, is not worse than that of a number of others, but notably weaker than Improved American.

Indiana.—The report from the Indiana station is the only unfavorable one from the corn belt. The average yield of the Kherson oat for the five years 1904 to 1908 was 41.66 bushels; of Sixty-Day, 44.86 bushels; of Great Dakota (the leading variety), 55.02 bushels, and of Silvermine, 52.2 bushels. Sixty-Day ranked twentieth and Kherson thirty-first in an average number of thirty-seven varieties under test. The weak points of both varieties, according to Professor Wiancko, are the low yield, the color of the grain, and the low weight per bushel. The only conditions, in his opinion, under which these varieties are likely to be of value in Indiana are where it is desirable to get the crop off the land early, where late seeding is necessary, or where the large-growing varieties are apt to lodge. The two varieties are very similar in their general characteristics, habits of growth, strength of straw, and quality of grain.

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[a] This opinion regarding the strength of straw of this variety is not the one commonly held. Its apparent resistance to lodging is, however, more largely due to its early maturity, which often enables it to escape storms, than to other causes.

John Waters, of Decatur County, reports that the Sixty-Day oat yields as well as any variety in his neighborhood. He states that if sown as early as the ground can be worked in the spring this variety will mature early enough to be harvested and thrashed with wheat, which he considers a strong point in its favor.

Michigan.—Both the Sixty-Day and the Kherson oats have been grown for three years at the Michigan station. No definite figures of the results have been published, but Professor Spragg writes, "We are still retaining them, but consider them decidedly lower in yield than certain later varieties."

G. F. Ottmar, of Clinton County, who has grown Sixty-Day for several years, writes under date of August 24, 1909, "I still raise the Sixty-Day oat and find it the best oat ever introduced into this State."

TESTS SOUTH OF THE OHIO RIVER.

The varieties here discussed have not been grown in field tests at any of the agricultural experiment stations in the section south of the Ohio River except that of Tennessee.

Kentucky.—At the Kentucky station a number of pedigreed selections of the Sixty-Day oat have been grown in the nursery for three years in comparison with similar selections of other varieties and of hybrids, all the selections having been furnished by the Bureau of Plant Industry of this Department. The best showing has been made by selections of a hybrid between Sixty-Day and Burt and by the Sixty-Day strains. While the results thus far secured hardly justify conclusions, it is probable that Sixty-Day and Kherson will yield as well as other spring varieties, particularly in the eastern portion of the State.

Tennessee.—Kherson oats on upland at the Tennessee station have made an average yield in the four years 1906 to 1909 of 31.78 bushels of grain and 0.8 ton of straw, as compared with 26.25 bushels of grain and 0.69 ton of straw produced by Burt. In the two years 1908 and 1909 Kherson has averaged 27.95 bushels; Burt, 23.75 bushels, and Red Rustproof, 22 bushels. A test of these three varieties on bottom land in 1908 was also favorable to Kherson. Prof. C. A. Mooers, agronomist of this station, writes as follows:

> I have not seen any difference between Kherson and Sixty-Day, and have grown both kinds for the past few years. The Burt is the nearest rival and is quite extensively grown in the best farming sections of middle Tennessee. Red Rustproof is the common spring oat in east Tennessee, and also in some other parts of the State. I am rather surprised at the favorable showing of the Kherson as compared with the others.

TESTS IN THE UPPER MISSISSIPPI VALLEY.

Illinois.—At the Illinois station the Sixty-Day oat has given an average yield of 53.1 bushels for the five years from 1905 to 1909, as compared with a general average of about 45 bushels for the medium-early varieties under test. The average of the best yielding varieties other than Sixty-Day or Kherson for the five years was practically the same as that of Sixty-Day, 53.2 bushels. In no case, however, did any one variety occupy this position for more than one of the five years. In 1907 and 1908 Sixty-Day gave the highest yield of any variety under test. Kherson has been grown for a shorter period than Sixty-Day and has given an average yield of 54.5 bushels. Prof. O. D. Center, of this station, says:

> The Illinois farmer is confronted with conditions that make it imperative to adopt one of two measures; either he must increase the humus and organic-matter content of his soil, thus providing a reservoir for moisture during a critical period in the development of the oat plant peculiar to Illinois conditions, or else he must adopt the plan of growing an earlier-maturing variety of grain. For best results the first solution of the problem is far superior to the last, since he will not only secure better yields of oats, but he will be increasing the productive power of his soil for other crops as well.

Mr. Samuel Ray, of Ogle County, received 2 bushels of Sixty-Day oats from this Department in 1905. This seed was sown on 1 acre and produced 83 bushels. The following year his yield was 72 bushels to the acre from 8 acres, sown at the rate of 1½ bushels to the acre. In 1907 the average yield secured was 65 bushels; in 1908, 50 bushels, and in 1909, 83 bushels. The average yield for the five years is 69.6 bushels.

A dealer in farm seeds near Chicago writes as follows:

> I recommend Sixty-Day oats for seeding as a nurse crop and in regions where larger and longer season varieties will not escape rust. During 1907 and 1908 these early oats gave very general satisfaction, but in a season like 1909, when the big oats pan out so well, the Sixty-Day oats do not give the satisfaction that I would like to have them. They grow a rather short, slender straw, and while I do not consider that an objection to them, many stockmen do, as they want considerable straw for feeding, and make that quite a feature of the crop. Sixty-Day oats have a place all through the central and northern oat belts, and I believe can be depended on to produce a crop under harder conditions than Swedish Select, Big Four, or like varieties.

The dealer quoted states, further, that a grower near Jerseyville, Ill., pronounces Sixty-Day oats splendidly adapted to that section; one near Lucerne, Ind., likes them there, and a South Dakota farmer reports a yield of 81 bushels to the acre in 1909, testing 40 pounds to the bushel.

Wisconsin.—At the Wisconsin station both the Sixty-Day and the Kherson oats have been tested since 1906. The average yield of Kherson for four years has been 56.4 bushels; of Sixty-Day, 58.3 bushels; of Silvermine, 44.2 bushels, and of American Banner, 40.4 bushels. Kherson averaged 29 pounds per bushel in weight; Sixty-Day, 28.8 pounds; Silvermine, 26.7 pounds, and American Banner, 23.2 pounds. All these figures include the year 1907, when the oat crop at this station was severely damaged by storms, the injury to the late varieties being greater than to the early ones. Swedish Select, which in the preceding four years, 1902 to 1905, was the leading variety, has averaged less than 40 bushels for the last four years.

In a recent letter Professor Moore, the agronomist, says:

> We have not up to the present time been able to see any difference between the Kherson and Sixty-Day oats and think they are one and the same variety. We find them good yielders, early in maturity, and heavy in weight per measured bushel. They are an exceedingly poor-looking oat and considerable comment is often made on them by farmers on account of their general looks. This, however, will be overcome after farmers know that this particular oat has a place in oat culture that no other variety so far has been able to take. That is, especially on rich, low ground, where most varieties rust and lodge extensively.

A Wisconsin dealer writes:

> We consider Kherson a desirable variety for some sections, especially for black prairie soils where other oats usually will not stand up. It is not an attractive looking oat and does not sell readily from sample. In fact, we doubt if it ever becomes popular as a market oat.

Minnesota.—At the Minnesota station, in a comparison with Early Gothland (Minn. No. 26) and Improved Ligowo (Minn. No. 6) the average yield of Sixty-Day oats for the eight years from 1902 to 1909 was 67.6 bushels, while that of Early Gothland was 68.52 bushels and of Improved Ligowo 57.33 bushels. For the six years from 1904 to 1909 Sixty-Day is slightly in the lead, with an average yield of 63.78 bushels, as compared with 63.14 bushels for Early Gothland. A nursery selection of American Banner has a six-year average of 61.84 bushels. Kherson has been grown but four years at this station, the average yield being 56.74 bushels. The selection of American Banner just mentioned (No. 312) leads for this period, with 60.29 bushels, while Sixty-Day averages 58.03 and Early Gothland 55.76 bushels.

Prof. Andrew Boss, of this station, makes the following statement:

> The early oats, both the Sixty-Day and the Kherson, are becoming quite popular in Minnesota, especially during the years when the rust has been severe. The strong points of these varieties are early maturity and yielding quality. The weak points are short straw, a slight tendency to lodge, though possibly not worse in this respect than many of the other varieties, and the fact that they are poor commercial varieties. Both are small kerneled and yellow in color, points which militate against them on the market. For home consumption I hear of very little objection to them. With the exception of the present year, the Sixty-Day oat has stood up remarkably well. We grew a large field of this variety this year and it lodged very badly. Since, however, the oats were headed out fully at the time of a very severe storm when other varieties of oats were not, I have attributed their lodging this year to the storm rather than to any natural tendency along that line.

A member of a prominent Minneapolis seed firm states that his firm has not found the Sixty-Day or the Kherson oats in demand or worthy of general distribution in his section of the Northwest. He further states:

> We believe they are especially adapted to the corn-growing belt, where oats are inclined to rust and blight on account of hot weather, which is quite sure to injure the late varieties when maturing. They always sell at a discount on account of their color; hence, are not desirable on the market.

Iowa.—Early oats have made a particularly good showing at the Iowa station. In a five-year test, from 1905 to 1909, four early varieties, ripening on or before July 16, averaged 46 bushels to the acre, eleven medium ones, ripening between July 16 and 25, averaged 43.5 bushels, and five late varieties, ripening after July 25, averaged 38.8 bushels. The highest yielding variety was Kherson, with an average of 55.1 bushels to the acre; Silvermine, which ripened eight days later, was next with 51.1 bushels, and Swedish Select, ripening with Silvermine, was third, with 47 bushels. Sixty-Day ranked sixth among the twenty varieties under test, with a yield of 45.2 bushels. Kherson was highest in weight per bushel, with 30.25 pounds. The growing of early varieties of oats is more essential in central and southern Iowa than in the northern portion of the State.

TESTS IN THE NORTHERN GREAT PLAINS STATES.

North Dakota.—The Sixty-Day oat has been grown at the North Dakota station since its introduction in 1901. A field of this variety at this station is shown in figure 5. Heavy rains during harvest caused the loss of the variety test in 1905, and floods early in the season destroyed it in 1909, so that only the yields from 1901 to 1904 and from 1906 to 1908 are available. The average yield of Sixty-Day for these seven years is 63.5 bushels, while that of Tartarian, a late side oat which ranks next to Sixty-Day, is 60.8 bushels. Other varieties which have yielded slightly less than Tartarian are Abundance, Siberian, and Lincoln. Seventyfive-Day, a variety quite similar to Sixty-Day, from the same grower as that variety, Mr. Mrozinski, has been grown at the station since 1902. Its average yield for the six years from 1902 to 1904 and from 1906 to 1908 has been 74.32 bushels to the acre, as compared with 65.7 bushels from Sixty-Day and 63.6 from Tartarian for the same period. The Seventyfive-Day oat is evidently one which could be grown to advantage in the Red River Valley.

At the Edgeley substation the highest yielding variety has been Abundance, with an average of 53.6 bushels in a five-year test, from 1905 to 1909. Siberian ranks next in order, with 51.8 bushels, while Sixty-Day is third, with 48.2 bushels. Silvermine has yielded practically as well as Sixty-Day, while the yield of Kherson, which has been grown only since 1906, is slightly less than that of Silvermine. All the varieties mentioned, however, yield better than either White Russian or Tartarian, which are varieties commonly grown in the section of North Dakota around Edgeley.

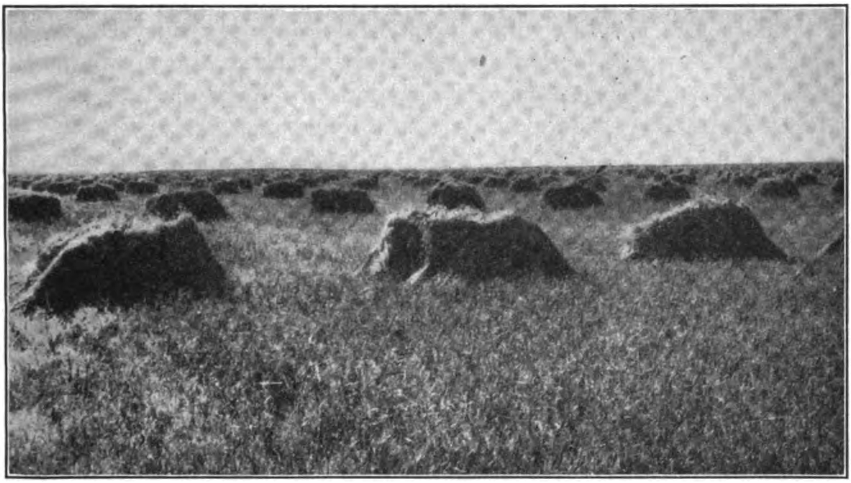

FIG. 5.—Field of Sixty-Day oats at the North Dakota Agricultural Experiment Station, Agricultural College, N. Dak.

At the Dickinson substation the leading variety in a test covering three years, 1907 to 1909, has been Early Mountain, with an average yield of 69.22 bushels. Next in order are No. 386, an unnamed variety from Germany very similar to Early Mountain, with a yield of 68.8 bushels, and Kherson, with 68.22 bushels. White Tartarian has averaged 63.23 bushels and Banner 59.25 bushels for a similar period. The highest yielding variety for the two years 1908 and 1909 was Golden Rain, recently imported from Sweden, with an average yield of 67.5 bushels. The yield of Sixty-Day at this station has been very much lower than that of Kherson.

At the recently established substation at Williston, Silvermine is the leading variety, averaging 70.4 bushels for the two years 1908 and 1909. Ligowo, Siberian, and Probsteier follow in order, while Sixty-Day ranks fifteenth among twenty-one varieties under test, with an average yield of 52.6 bushels. These results were secured without irrigation. Kherson has not been included in the tests, but it is hardly probable that these early varieties will ever rank high in yield in this section. They are certainly not to be recommended on irrigated farms, but may make a favorable showing outside the irrigated district in dry seasons.

South Dakota.—The leading variety at the South Dakota station[a] for the three years from 1906 to 1908 was the Red Algerian oat, a variety of the Rustproof type originally from northern Africa, with a yield of 51.7 bushels, while the Kherson and the Sixty-Day averaged 49.1 and 48.4 bushels, respectively. The average weight per bushel of Red Algerian was 28.75 pounds; of Kherson, 27.8 pounds, and of Sixty-Day, 25.58 pounds. In a longer test, embracing the six years from 1904 to 1909, Sixty-Day averaged 59.4 bushels; Swedish Select, 44.7 bushels; North Finnish Black, 40 bushels; and Banner, 27.6 bushels. Kherson and Red Algerian were not included in the tests previous to 1906. In a recent publication[b] Professor Willis says, "Of all varieties grown at this station, Sixty-Day has proven the best."

At the Highmore substation Swedish Select has outyielded Sixty-Day about 4 bushels to the acre in a seven-year test, from 1903 to 1909, while in a four-year test, from 1906 to 1909, Kherson leads with a yield of 41.5 bushels; Swedish Select is second, with 41.3 bushels, and Sixty-Day third, with 37.8 bushels. The results are not strictly comparable, however, as in 1906 Sixty-Day was not grown in the regular series. Instead, it was grown after sorghum and gave a yield of 43.3 bushels. Kherson in the regular series yielded 69.7 bushels, and Swedish Select 65 bushels, while the latter on sorghum ground yielded but 42.8 bushels, or practically the same as Sixty-Day. It is probable that if Sixty-Day had been grown under the same conditions as the other varieties in 1906 its average yield for the four-year period would have been as good as either Swedish Select or Kherson.

At the recently established experiment farm at Bellefourche, the average yields for 1908 and 1909 of the Kherson and the Sixty-Day oats were practically the same, 36.4 and 36.3 bushels, respectively, while the Swedish Select averaged 33.3 bushels, and only one other variety yielded more than 30 bushels. The average weight per bushel of the Sixty-Day and Kherson was 33.8 pounds, while Swedish Select averaged 34.3 pounds. These figures are from nonirrigated plats. It is probable that Swedish Select will be the better variety to grow on irrigated land in this section. On the dry farms in the vicinity of both Highmore and Bellefourche, Sixty-Day and Kherson are also to be recommended, though in dry years they may not grow tall enough to be cut with the binder.

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[a] Bulletin 110, South Dakota Agricultural Experiment Station, p. 434.

[b] Op. cit., p. 423.

The manager for a South Dakota seed firm reports that practically all the oats sold by his firm in 1909 were of the Sixty-Day variety, due to its superiority the previous year and to published reports of its value as compared with later varieties. In the 1909 catalogue of this firm the following statement is made:

> It is adapted to the widest range of soil and climate of any oat grown in the United States to-day. It is the earliest of all oats. It gets out of the way of rust, drought, hailstorms, and hot winds.

Isaac Lincoln, of Brown County, has grown the Sixty-Day oat since its introduction. His average crop from 1902 to 1908 was 89 acres, with an average yield of 61.6 bushels to the acre. He states that in his locality the variety ripens in from ninety-three to one hundred days, or from one to three weeks earlier than other varieties, thus escaping rust, drought, and summer storms.

A large landowner near Manchester, Kingsbury County, writes that he has grown Sixty-Day oats for several years and that while he has no definite records he believes that the lowest yield under average conditions has been about 40 bushels. The average yield of more than 200 acres for 1909 was about 40 bushels by measure, or considerably more than that by weight.

G. A. Grant, of Minnehaha County, has been growing the Sixty-Day oat since 1901, with an average yield of about 50 bushels during that time. He states that owing to the light straw of this variety it takes less twine to harvest it, but he advises the use of small bundles and small shocks, as he finds it hard to cure. While grain dealers do not like it and pay 1 or 2 cents a bushel less than for white oats, he thinks it worth more for feed than other varieties.

H. H. Stoner, of Hyde County, states that early oats like the Kherson and the Sixty-Day, both of which he grew in 1909, are likely to escape the dry weather which usually comes in that section during the latter part of July and early in August, and that they will almost invariably give better yields than the later varieties. His yield of Sixty-Day was 51 bushels; of Kherson, 56 bushels; and of Swedish Select, 39 bushels. The Swedish Select weighed 35 pounds to the bushel, about 2 pounds less than the early varieties.

Nebraska.—For the seven years from 1902 to 1908 the Kherson oat has been the leading variety at the Nebraska station,[a] with an average yield of 55.3 bushels. The yield of Sixty-Day has been slightly less, 52.5 bushels, while Texas Red has averaged 52 bushels. Burt, which was tested but four years, 1905 to 1908, averaged about 4.5 bushels more than Kherson for that period and matured four days earlier. The average date of harvesting for Kherson and Sixty-Day was July 10, and for Texas Red, July 15. The superiority of early oats over late ones in the section of Nebraska around Lincoln is well shown by a comparison of yields. Of the varieties which have been grown four years or more, the five which were harvested on or before July 15 averaged 53.9 bushels per acre, while the seven varieties ripening after that time averaged 40.1 bushels.

At the North Platte substation Kherson is the leading variety, although Burt and Texas Red are close rivals. Sixty-Day is considered as identical with Kherson. The latter variety averaged slightly better than 40 bushels to the acre from 1904 to 1908, with the year 1907, when the entire oat crop was killed by a late frost, excluded. Kherson is recommended as the best oat for western Nebraska.[b]

A prominent Nebraska seed firm writes that practically four-fifths of its oat sales in the past three years have been of the Kherson variety, and that there has also been a large trade among farmers in this oat. This firm especially recommends the Kherson for growing on heavy soil and low ground, stating that it stands up much better and yields more than other varieties.

TESTS IN THE SOUTHERN GREAT PLAINS STATES.

Kansas.—At the Kansas station the three leading varieties in a test covering the six years from 1904 to 1909 have been the Red Texas, with an average yield of 43.5 bushels, the Sixty-Day, averaging 41.79 bushels, and the Kherson, averaging 41.43 bushels. The highest yield in this test was secured in 1909 from the Sixty-Day, 66.32 bushels to the acre.

Concerning the Kherson and the Sixty-Day oats, Professor Ten Eyck writes:

> It appears that the Kherson oat is somewhat more generally adapted for growing in the State than the Sixty-Day variety, although there is really very little difference in these varieties either in appearance or in yields or hardiness. These varieties are somewhat better adapted for growing in the northern and western parts of the State than the Red Texas. At this station, however, and through the central, southern, and eastern portions of the State the Red Texas

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[a] See Bulletin 113, Nebraska Agricultural Experiment Station.

[b] Bulletin 109, Nebraska Agricultural Experiment Station, pp. 21, 22.

> oats should generally be preferred. An advantage of the Kherson on fertile soil is that it does not make a very rank growth of straw and is not apt to lodge. On the other hand, on poor land or in dry seasons the Kherson and Sixty-Day may not grow high enough to harvest well. Another fault with these oats is the small berry. Farmers prefer a larger grain. Their earliness makes Kherson and Sixty-Day somewhat safer for growing in central and western Kansas than later maturing sorts. In eastern and northern Kansas the early-maturing varieties usually rust less than those that mature later. Early oats have an advantage in Kansas in that they mature before hot weather. The Red Texas is only a few days later than the Kherson and is not at much disadvantage in this respect. These varieties are easily the best producers and the safest for planting in Kansas.

At the McPherson cooperative station the average yield of Kherson and Sixty-Day oats for the four years from 1906 to 1909 has been about 38 bushels to the acre, while various strains of Red Rustproof and Burt gave yields averaging from 1 to 5 bushels less. These figures include the 1907 crop, when all varieties of oats were practically a total failure at this station.

Oklahoma.—The Kherson oat has been grown for five years at the Oklahoma station, where it has given practically as good yields as Red Rustproof. Sixty-Day has been grown only two years, but has made an excellent showing for that time. Mr. Burlison, of this station, says of the variety trials:

> It seems from the experimental data thus far collected that the Kherson is one of the best two varieties of oats which we have tested. A large number of variety trials have been made comparing Texas Red and Kherson oats with other strains from different States. Taking all the work into account Texas Red and Kherson stand at the head of the list.

Texas.—Variety trials in the Panhandle section of Texas, conducted by the Office of Grain Investigations of the Bureau of Plant Industry from 1904 to 1906 at Channing and since that date at Amarillo, show Sixty-Day to be the highest yielding oat, slightly better than Red Rustproof. Kherson has been tested at Amarillo only, where it has given a yield materially lower than Red Rustproof.

New Mexico.—Few tests have been made of either the Sixty-Day or the Kherson oats in New Mexico. E. P. Barela, of Bernalillo County, has grown Sixty-Day for the past three years and has secured a good crop each year. This variety, in his opinion, is more drought resistant than those commonly grown in the vicinity.

TESTS IN THE MOUNTAIN AND PACIFIC NORTHWEST STATES.

Montana.—As previously stated, the larger, later varieties usually yield heavier on irrigated land than the Sixty-Day or the Kherson. A five-year test under irrigation at the Montana station at Bozeman shows an average yield of 82 bushels to the acre from Kherson and

78.8 bushels from Sixty-Day, while Progress, a large white oat similar to Swedish Select, averaged 93.1 bushels for the same period. The yield of straw from Progress was slightly heavier than from the other varieties. Professor Atkinson, of this station, says that Sixty-Day is the best yielding dry-farm oat in Montana, but neither this variety nor Kherson is considered especially valuable for the irrigated farm. An especially favorable season in 1909 following a very unfavorable one the previous year at the Judith Basin substation at Philbrook, established in 1908, resulted in an average yield for the two years of 52.4 bushels for Sixty-Day, 50.5 bushels for Kherson, 46 bushels for Swedish Select, and 43 bushels for White Russian.

Wyoming.—Prof. L. B. McWethy, of the Wyoming station, writes as follows:

> The Kherson oat has been grown at this station for at least three years. Its earliness and resistance to drought and severe weather conditions, combined with good yielding qualities, make this oat a valuable one for high altitudes in this State. The objections to this variety are its short straw and the yellow color of the grain, which place it somewhat at a disadvantage as an oat for the market. Under more favorable conditions, where the water supply is sufficient, there are other varieties of oats superior to the Kherson or Sixty-Day.

Colorado.—The Sixty-Day and the Kherson oats have not been included in the variety trials at the Colorado station for a sufficient length of time to secure conclusive results. Prof. Alvin Keyser, the agronomist, states that Kherson is proving a good oat for dry-farming conditions on the plains of the State and is also showing up extremely well in the higher altitudes of the mountain parks, where its early ripening habit makes it of particular value.

At the Akron substation, tests in 1908 and 1909 showed Colorado No. 37 to be the highest oat in yield, averaging 54.2 bushels to the acre. The yield of Swedish Select was slightly lower, while Kherson averaged 45.6 bushels and Sixty-Day but 38.65 bushels. In 1909 the early varieties were injured more severely than the later ones by both drought and hail, which accounts for their low average yield. Kherson was the highest yielding variety at Akron in 1908 and will probably prove its value in a test extending over several years.

H. C. Walker, of Montrose County, who has grown the Sixty-Day oat for three years, reports that it is better than any other variety ever grown in his section. He further states:

> This variety of oats is well suited to this climate and altitude. It stands up well and the grain has large kernels and thin husks. The yield is not as large as black oats but the feed value is far better.

Idaho.—The Idaho station has not grown the varieties here discussed, but a number of farmers have tested the Sixty-Day oat. As in other States, where irrigation is possible, larger later varieties give greater yields, but on the dry farms Sixty-Day and Kherson are sure to find favor. Joseph S. Rudd, of Fremont County, says:

> Sixty-four pounds of the Sixty-Day oat received from the Department, planted on one acre, produced 90 bushels. This variety is becoming a favorite on the dry farms because of its early maturity and the making of an average yield of 50 bushels to the acre. The only weak point that I have discovered in these oats is that they only weigh about 35 pounds to the measured bushel while some others weigh about 40 pounds.

F. R. Fouch, of Canyon County, tried the Sixty-Day oat for three years and discontinued it, stating that it was from 18 to 22 days earlier than the Danish Island but did not yield as well, was not as heavy, and shattered more. He further says that in case of a short water supply Sixty-Day would probably be the most satisfactory variety to grow.

F. W. Boehme, of Bear Lake County, is very enthusiastic over the Sixty-Day oat, stating that no other variety can take its place and that it is the best oat for the dry-farming section. The yield in his section is from 24 to 60 bushels, according to the season and the condition of the seed bed, while the weight is about 40 pounds to the measured bushel. His principal objection to this variety is that during the ripening period it is likely to be damaged by storms, as it shatters readily. An important characteristic of the variety, in his opinion, is that the grain will not heat in the bundle or in the bin. The fine, bright straw is readily eaten by sheep, horses, and cattle.

Utah.—Prof. J. C. Hogensen, agronomist of the Utah station, reports an average yield, under irrigation, of about 97 bushels to the acre from the Sixty-Day oat for the three years from 1906 to 1908. Other leading varieties averaged about 90 bushels for the same period. He says:

> Sixty-Day is early and drought resistant and is considered a good oat in our State, especially for dry farms. It has a short stiff straw and does not lodge. Kherson has been grown only two years, but the yield is much lower than that of Sixty-Day.

On the Utah substations the Sixty-Day oat has made a very good showing, usually ranking as one of the leading varieties on these dry-land farms. At Nephi it has given a decidedly lower yield than Black American in a six-year test, but higher than that of other varieties. The average yield of Sixty-Day for the six years is about 23 bushels. Kherson has not been grown on these farms for a period long enough to indicate its value.

Washington.—Few tests of these varieties have been reported from Washington and Oregon. The experiment station at Pullman, Wash., has grown the Sixty-Day oat for several years. Director Thatcher says:

> It is a very satisfactory early oat and will be used quite extensively in the drier parts of the State. Kherson oats have not done as well with us as other varieties. Swedish Select and the black oats, supplied to us by the Bureau of Plant Industry several years ago, are giving us the best results in regions of 18 inches or more of rainfall.

Oregon.—H. H. White, of Sherman County, has grown the Sixty-Day oat since 1906. In 1908 he reported:

> This is not an oat country. My neighbors thrashed 3 to 8 sacks (7 to 20 bushels). Mine went 12 sacks (30 bushels). I received 64 pounds of seed from the Department in 1906, which was sowed on 2 acres of measured land. The yield was 67 bushels. Most of this crop was sowed on 40 acres at the rate of 40 pounds to the acre. My crop this year was 478 sacks (1,075 bushels). My neighbors bought almost all of the crop for seed. This is the oat for here, as it gets ripe before the hot weather hits us.

COMPARISON OF SIXTY-DAY AND KHERSON OATS.

An opportunity for a comparison of the merits of the Sixty-Day and the Kherson oats is afforded by the figures given in Table II. In this table strictly comparable tests from fourteen stations are reported. The duration of the tests varies from two to seven years and averages four years.

TABLE II.—*Comparison of the yields of the Sixty-Day and the Kherson oats in fifty-five tests at fourteen agricultural experiment stations for periods averaging four years.*

Station.	Number of years tested.	Sixty-Day.	Kherson.
		Bushels.	*Bushels.*
Lafayette, Ind	5	44.86	41.66
Madison, Wis	4	58.30	56.40
St. Anthony Park, Minn	4	58.03	56.74
Ames, Iowa	5	45.20	55.10
Edgeley, N. Dak	4	37.60	37.10
Brookings, S. Dak	3	48.40	49.10
Bellefourche, S. Dak	2	36.80	36.40
Lincoln, Nebr	7	52.50	56.30
Manhattan, Kans	6	41.79	41.43
McPherson, Kans	3	35.38	32.60
Amarillo, Tex	3	24.87	18.61
Bozeman, Mont	5	78.80	82.00
Philbrook, Mont	2	52.40	50.50
Akron, Colo	2	38.65	45.60
Average	....	48.26	49.13

The Sixty-Day oat has given a higher yield than the Kherson at eight of the stations, viz, Lafayette, Ind., Madison, Wis., St. Anthony Park, Minn., Edgeley, N. Dak., Manhattan and McPherson, Kans., Amarillo, Tex., and Philbrook, Mont. At the remaining six, Ames, Iowa, Brookings and Bellefourche, S. Dak., Lincoln, Nebr., Bozeman, Mont., and Akron, Colo., Kherson has given the better yield. The average of the 55 tests is 48.26 bushels for Sixty-Day and 49.13 bushels for Kherson.

CONCLUSIONS.

In the corn belt, which is also the area of greatest oat production, those varieties of oats which mature early give the best yields.

The most satisfactory type of early oats now grown in this country is that represented by the Sixty-Day and the Kherson.

These two varieties, which are practically identical, were both introduced from southern Russia, the Kherson by the Nebraska Agricultural Experiment Station and the Sixty-Day by the United States Department of Agriculture.

The principal points in their favor are their early maturity, heavy yield, low proportion of hull, and resistance to lodging.

Their principal defects are the small size and the yellow color of the berry.

The Sixty-Day and the Kherson oats have given best results in the corn belt and on the dry farms in the Great Plains and Intermountain districts.

Larger, later varieties usually give higher yields in the Northern States and in irrigated districts.

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THE MUSKRAT.

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Biological Survey,
Washington, D. C., February 25, 1910.

Sir: I have the honor to transmit a report on the economic value of the muskrat, by David E. Lantz, and to recommend its publication as a Farmers' Bulletin. The diminished numbers of fur-bearing animals and the enhanced value of all furs invite attention to every practicable means of conserving and increasing the supply. The muskrat is widely distributed and very abundant over large areas, and has become one of the first fur bearers in commercial importance. Its fur, while not of the highest quality, is adapted to a great variety of uses, and its flesh, unlike that of most fur bearers, has considerable food value.

Except in localities where its burrows endanger the safety of embankments, the muskrat should be protected by the establishment and enforcement of closed seasons, with proper provisions for trapping during the nonbreeding period. If muskrats are properly protected and not trapped to excess, the supply may be indefinitely maintained, and even increased, especially by the wise utilization of flooded marsh lands which are of little or no value for agricultural purposes.

Respectfully,

C. Hart Merriam,
Chief Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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THE MUSKRAT.

INTRODUCTION.

The present bulletin discusses the habits, economic relations, and value of the muskrat, or musquash (*Fiber zibethicus*). While this animal does considerable damage in some places, its harmlessness throughout most of its range and its increasing value as a fur and food animal justify its protection generally. Its wide distribution, prolific breeding, and hardiness, together with the fact that the areas it inhabits are not available for agriculture, make it a resource whose value may be greatly increased by careful husbanding.

GROWTH OF THE USE OF FURS.

The wearing of fur garments is as old as human history, but furs were slow in gaining favor in the temperate and warmer parts of Europe. Even in the middle ages their use was greatly restricted by sumptuary laws, which, on the plea of restraining extravagance, permitted the common people to wear only the inferior kinds. In several European countries sable was reserved for the nobility and ermine for the sole use of the royal families. Later, judges were allowed to wear ermine as officers and representatives of the king, and this concession was afterwards extended to all attendants on the court and servants of the royal family. The subsequent use of this fur by the nobility and clergy and finally by merchants and wealthy citizens are matters of history.

Royalty and nobility having approved the wearing of animal skins in temperate countries, the use of furs spread rapidly when once the restraining laws were repealed. The opening up of the interior of North America to trade brought largely increased supplies, until the number of fur-producing mammals slaughtered yearly became enormous. So great has been the demand for certain furs that the animals which furnish them have been hunted almost to extinction. Other important fur bearers are still found in large numbers, but each year trappers are obliged to go farther and farther in search of them. While the fur supply of the world is in no immediate danger of failure, present conditions are unfavorable to its indefinite continuance.

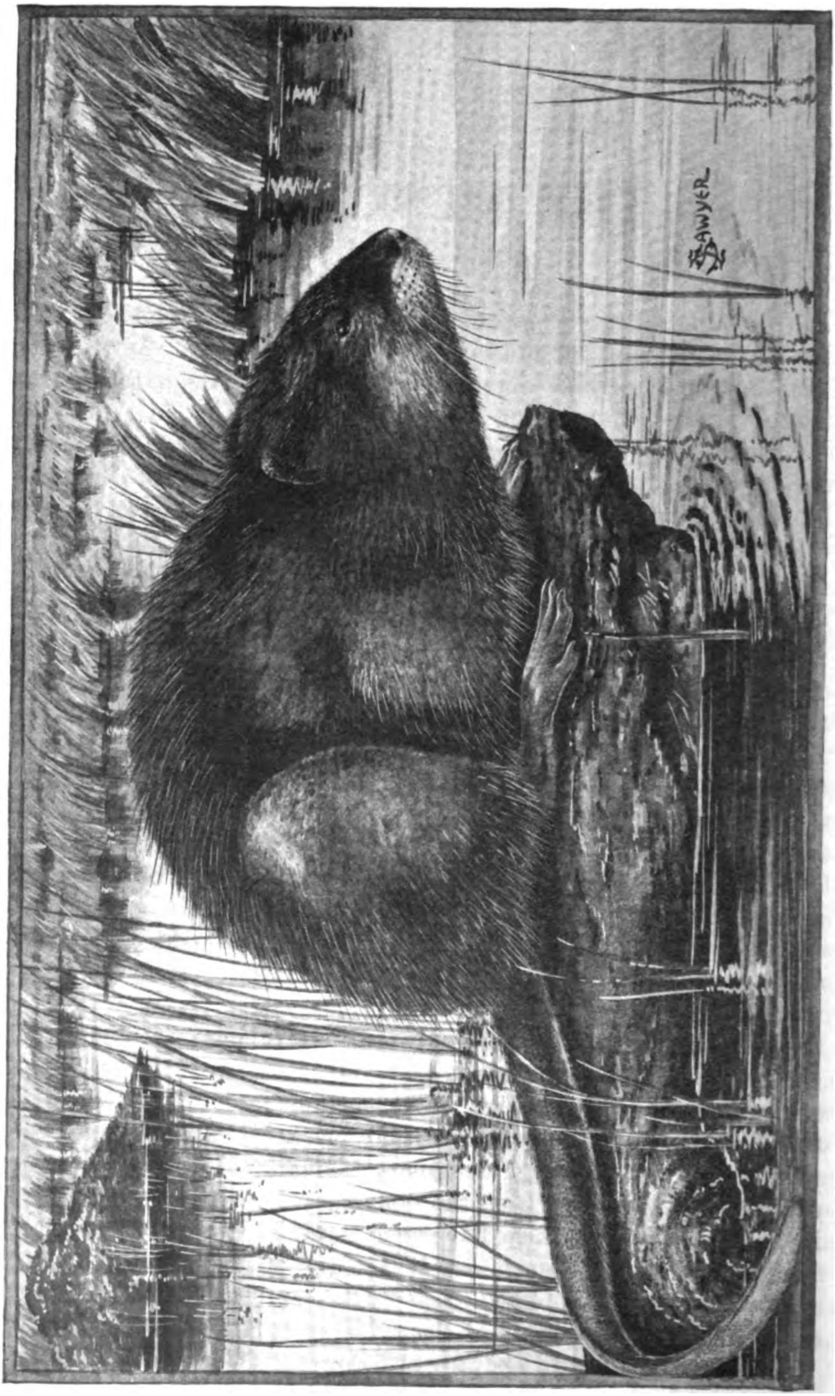

FIG. 1.—Muskrat.

SAVING THE FUR SUPPLY.

Although the outlook for a future fur supply adequate to the world's needs is unpromising, it is by no means hopeless. Four ways of increasing the present supply suggest themselves:

1. The use of pelts of domestic animals as a substitute for wild furs. In some parts of the world, dogs, goats, horses, and cattle are now bred principally for their pelts, which are used for both clothing and rugs. The full development of this idea would involve prolonged experiments in producing finer pelages by selective breeding.
2. Breeding fur-bearing animals under protection, either in a state of domestication or in a semiwild condition. Such animals would prove especially valuable for restocking parts of the country from which any species has been exterminated by excessive trapping.
3. Investigations to discover if any animals not now considered valuable for fur have pelts that may be utilized in the manufacture of clothing.
4. Conservation of the present supply. If furs from the three sources already mentioned can gradually be made to supplement the present output, much will be gained; but the chief dependence, after all, must be on a more careful conservation of the natural supply. This may be saved by laws restricting the taking of fur animals to proper seasons and protecting them at other times; and, in the case of species that are becoming rare, by laws forbidding their capture for a series of years. In addition, systematic restocking of territory depleted by trapping should be undertaken. It is believed that the muskrat may be made to play an important part in the conservation of the Nation's fur resources.

IMPORTANCE OF THE MUSKRAT.

While individual skins of the rarer fur bearers, like the sea otter and black fox, now command enormous prices, so few reach the market that their aggregate value is small compared with that of the commoner kinds. Even the beaver and the fur seal have so diminished in numbers as to be of less commercial importance than either the mink or the muskrat. The last two, in spite of their small size, assume importance as sources of fur by reason of their wide distribution and continued abundance. Mink remains our most popular as well as our most durable fur, but muskrat pelts not only have fair wearing qualities but are adapted to a great variety of uses. This fact and their abundance made the aggregate value of the muskrat skins sold in 1909 apparently greater than that of the mink. Only one other animal in the world, the European rabbit, exceeds the muskrat in the number of skins marketed. The London sales of muskrat pelts for the year 1905 exceed 5,000,000.

CLASSIFICATION AND DISTRIBUTION.

The muskrat belongs to a group of rodents known technically as the Microtinæ. The group has been separated into two divisions, the lemmings and the field mice, the latter including the common short-tailed meadow mouse (*Microtus*) of the Northern Hemisphere. The muskrats are very closely related to the field mice, but are larger, and have fur, feet, and tails more highly specialized for a life in the water. They differ from field mice of the genus *Microtus* particularly in having long, narrow, rudder-like tails, which are nearly naked, about as long as the body without the head, and thickest along the middle line.

Five species and eight subspecies (geographic races) of muskrats have been described.[a]

Muskrats are distributed over the greater part of North America, from the southern border of the United States to the barren grounds of northwest Canada and from the Atlantic to the Pacific. They seem to be absent from the coastal parts of South Carolina, Georgia, Alabama, and Texas; and from Florida and nearly the whole of California. Of course they do not occur in parts of the interior plateau that are devoid of streams or lakes.

DESCRIPTION.

The common muskrat when full grown is about four times as large as the ordinary brown rat. In general form it resembles the common meadow mouse (*Microtus pennsylvanicus*), but its tail is relatively very much longer and of different shape. The animal has a blunt muzzle, a short and hardly noticeable neck, and a stout body. The tail is characteristic of the genus, about two-thirds as long as the head and body, compressed, thickest along the middle line, and tapering to a rather acute point; the thinly scattered hairs do not conceal the small but distinctly marked scales. The eyes are small, black, and beady. The ears are short, covered with hairs, and in winter almost wholly concealed in the fur. The incisors are large and without grooves. The legs are short, expecially the front ones, while the feet are stout and provided with rather long claws. The hind feet are slightly webbed and so formed that they can be turned edgewise when carried forward while the animal is swimming.

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[a] The list of these forms follows:

Fiber macrodon Merriam. Type from Lake Drummond, Dismal Swamp, Virginia.
F. obscurus Bangs. Type from Codroy, Newfoundland.
F. occipitalis Elliott. Type from Florence, Oreg.
F. spatulatus Osgood. Type from Lake Marsh, Yukon, Canada.
F. zibethicus (Linn.). Type from eastern Canada.
F. z. aquilonius Bangs. Type from Rigoulette, Hamilton Inlet, Labrador.
F. z. hudsonius Preble. Type from Fort Churchill, Keewatin, Canada.
F. z. mergens Hollister. Type from Fallon, Nev.
F. z. osoyoosensis Lord. Type from Lake Osoyoos, Washington.
F. z. pallidus (Mearns). Type from Fort Verde, Ariz.
F. z. ripensis Bailey. Type from Carlsbad, N. Mex.
F. z. rivalicius Bangs. Type from Burbridge, La.
F. z. zalophus Hollister. Type from Bercharof Lake, Alaska.

Except the beaver, none of our inland fur-bearing mammals leads a more aquatic life than the muskrat. Its characters especially adapt it to the water. Besides having feet specialized for swimming, it has a tail which serves as an efficient rudder and fur which is practically waterproof. The long overhairs are close and glossy, and the underfur is exceedingly dense. The more common color of the muskrat is dark umber brown, the exact shade differing with the season and the locality.

Fur dealers recognize only one variety of the muskrat differing from the common color. This variety consists of the dark, sometimes almost black, skins collected in the Chesapeake and Delaware regions and in more limited numbers elsewhere. They are sold as " black muskrat," and command a higher price than the ordinary color. The species from which most of the black skins are derived is *Fiber macrodon*, which ranges chiefly in the tidewater region of the Atlantic coast from New Jersey to North Carolina.

The muskrat derives its name from the musky odor given off chiefly by its large perineal glands. The odor pervades the entire skin to some extent, particularly in summer. The name musquash, used by Richardson for this animal, is the Cree Indian name, and has the authority of long use, especially among fur dealers.

GENERAL HABITS.

While muskrats are chiefly nocturnal, they are much more active by day than many suppose. Where seldom disturbed, they may often be seen at work in bright sunlight, especially when building winter houses. These structures, though smaller and less strongly built, are in many respects similar to those of the beaver. (Fig. 2.)

HOUSES AND BURROWS.

Muskrat houses are composed of rushes, grasses, and roots and stems of other aquatic plants. The structure rests on the bottom of the pond, and is built mainly of the kinds of plants on which the animals feed. These are heaped up without orderly arrangement until the dome-like top rises from 18 inches to 2 or 3 feet above the water. The mud sometimes seen on the outside of muskrat houses seems to be collected accidentally with the roots. From the part of the structure above the water an interior chamber is excavated, from which two or three passages lead downward through the mass to the water, reaching it at points well below the frost line. If the water is shallow, the animals excavate deeper channels leading from the house to various parts of the pond.

The houses are mostly for winter shelter and food and are seldom used as receptacles for the young. A single family usually occupies a house. Occasionally, however, when driven from other houses or when excluded from underground burrows by barriers of ice or frozen ground, a larger number may temporarily occupy a house.

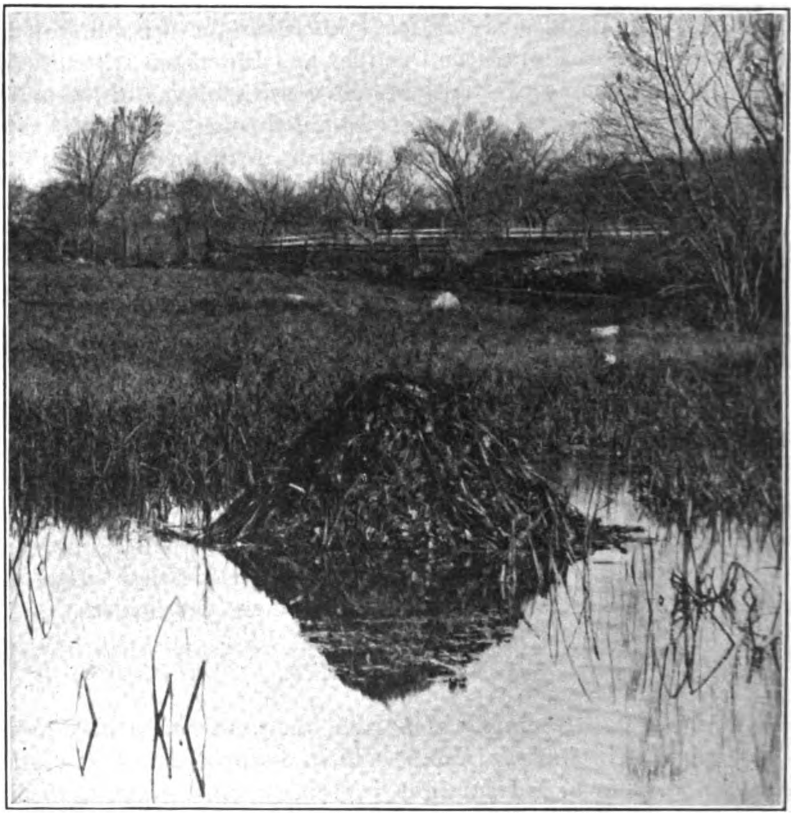

FIG. 2.—Muskrat house on Concord River, Massachusetts. (Photograph by William Brewster.)

When banks of streams or ponds are high enough for the purpose, muskrats burrow into them. Entrances to the tunnels are almost always under water, and the approach to them is, if possible, by channels of sufficient depth to prevent ice from closing the passage. The tunnels extend upward into the bank above the level of the water. They often rise to within a few inches of the surface of the ground and are frequently protected above by roots, or by trees and shrubs, or by thickly matted turf. These tunnels extend 10 to 50 feet into the bank and terminate in a roomy chamber which sometimes contains a bulky nest composed of dried vegetation. Usually two tunnels lead from the nest to the water, and often a tunnel has two branches or outlets.

When burrows are available, muskrats occupy them in winter and summer; but in shallow ponds and marshes, and especially in northern latitudes, the entrances are often closed by ice in winter. In such situations and when banks suitable for burrows are wanting, houses become a necessity. But they are seldom seen along the borders of deep ponds and canals, and, except in extensive swamps unbroken by hillocks, they are not found in the southern parts of the muskrat's range.

As cold weather approaches, muskrats are very active, adding to their old winter houses, building new ones, and deepening channels that lead to houses and burrows. The animals do not hibernate, and, aside from the vegetation of which their houses are made, they seem to make little provision for winter. However, some of the surplus food collected may be found in their burrows at almost any time.

BREEDING HABITS.

Published accounts of the muskrat's breeding disagree so widely that the habits of the animals might be supposed to differ in different sections of the country. Harlan states that the female brings forth 5 or 6 young annually.[a] Richardson, on the other hand, says: "In latitude 55° the musquash has three litters in the course of the season and from three to seven young in a litter."[b] Audubon and Bachman, and many zoologists since their time, repeat Richardson's statement, with slight variations that show no original research. Amos W. Butler, writing of the muskrat in Indiana, states that he is convinced that in his vicinity the animals breed but once a year, though he admits the probability of exceptions. He gives the number of young as 4 to 6 and the period of gestation as about six weeks.[c] Roderick MacFarlane, a chief factor of the Hudson Bay Company, in writing of the mammals of the Mackenzie River region, states that the female has two litters the first and three each succeeding season, and that the number of young at times varies from 8 to 20.[d]

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[a] Fauna Americana, p. 133, 1825.

[b] Fauna Boreali-Americana, p. 117, 1829.

[c] American Field, XXIV, 537, 1885.

[d] Proc. U. S. Nat. Museum, XXVIII, 738, 1905.

His statements are based on information obtained from the company's Indian hunters, who are keen observers.

Some of the foregoing testimony has little weight. Also, we should be slow to accept conclusions based on the number of "kit" muskrats found occupying a winter house, for they may be either more or fewer than a full litter. The close relationship existing between this animal and the common field mouse (*Microtus*) suggests that a similarity of breeding habits is to be expected; and the investigations of the Biological Survey show that such resemblance actually exists.

Field naturalists of the survey have made two records of actual litters of muskrats. A female taken June 18, 1895, by Vernon Bailey, at Summit, Mont., contained 13 large embryos. Another, taken June 8, 1893, by J. A. Loring, at Ward, Colo., contained 8 embryos. A specimen in the United States National Museum, collected by Dr. E. A. Mearns at Newport, R. I., April 19, 1900, contained 6 small fœtuses.

The writer, in March, 1909, talked with a considerable number of muskrat trappers in Dorchester County, Md., about the breeding habits of the animals. The best informed of these men state that from three to five litters (normally but three) are produced, and that the number of young in a litter varies from 3 to 12 or even more, the average being probably 6 to 8.

In mild winters sporadic breeding occurs. Thus, in the open season of 1908–9, in January one trapper found a female that had recently suckled young, and on the same day found young near by that were only about one-third grown. Another trapper in February captured a female that contained 3 embryos, and still another, a Mr. Insley, on March 6 took a female that had 3 embryos. In discussing the date in spring at which trapping should cease, the trappers stated that each year before March 15 a number of pregnant females are caught, and that trapping should not be continued later than that date. The early spring litters, they stated, are usually below the average in size, 3, 4, and 5 being the more common numbers. The young of these early litters are said to breed the same fall.

I am indebted to R. J. Slacum, of Cambridge, Md., for a detailed account of his observations during many years while residing near the marshes and trapping in them. He confirmed the statements of the more intelligent trappers as to the number of litters and number of young; and made the interesting statement that most of the young muskrats in Dorchester County marshes are born, not in burrows, for there are few places where burrowing is possible, nor yet in winter houses, although this is occasional, but in new nests which the female builds of grasses and dry plants, but without roots or mud. Such a nest is placed above the reach of tides in a brush pile or a bunch of growing plants. Mr. Slacum states that he has often found young muskrats in these nests, which are far less bulky than the winter houses. He is uncertain as to the duration of pregnancy in the female, but thinks it must be less than a month.

All this testimony shows that in their breeding habits muskrats are not unlike field mice. This conclusion is further strengthened by the remarkable way in which the marshes, depleted by vigorous winter trapping, are replenished before the opening of another season. The known facts may be thus summarized: Normally the animals mate in March and the first litter is born in April; a second litter is due in June or early July, and a third in August or September. In favorable seasons a fourth or even a fifth litter may be produced. The period of gestation is possibly no longer than twenty-one days, as with the common rat and probably with the field mouse. The young are blind and naked when born but develop rapidly. Outside of low marshes, muskrats are usually born in the underground burrows.

MIGRATIONS.

Muskrats often wander over fields and along highways far from water. This occurs in late fall, early spring, or during severe droughts in late summer. The causes are not understood, although the spring movement has been generally attributed to sexual excitement. When met away from water, muskrats sometimes show considerable ferocity and have been known to attack persons savagely without apparent provocation.

Whether general migrations of muskrats occasionally occur is doubtful, although the trader at Lake Traverse, Minnesota, informed Featherstonhaugh that such movements take place, and that at times the animals were seen on the prairies in incredible numbers.[a]

The local movements of muskrats from place to place, both overland and along streams, make it difficult to protect canals and artificial ponds from the animals. They promptly find their way to new ponds built several miles from their former known haunts. Irrigation canals and ditches are likewise invaded throughout their entire length so nearly simultaneously that it is hard to believe that all the animals could have reached them through the head gates.

FOOD.

Like nearly all rodents the muskrat is chiefly herbivorous, but it sometimes indulges in animal food, a habit which it shares with brown rats, house mice, field mice, lemmings, wood rats, squirrels, and other gnawers.

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[a] Featherstonhaugh's Canoe Voyage, I, 384, 1847.

In winter the chief food of muskrats consists of the roots of aquatic plants—pond lilies, arums, sedges, and the like—but in some localities the animals feed on mussels and also on carp and other sluggish fish that bury themselves in mud. When ponds are frozen over, muskrats are almost wholly restricted to food accessible under the ice, but in rare cases they have been known to leave the water and burrow under the snow in search of the crowns of grasses and sedges.

In wooded marshes near Washington, D. C., the winter food of muskrats seems to be largely roots and stems of the golden club (*Orontium aquaticum*). At New Richmond, Mich., in November, 1908, W. L. McAtee, of the Biological Survey, found the animals feeding almost entirely on fleshy tubers of a large sedge, the river bulrush (*Scirpus fluviatilis*). The writer examined 15 of the stomachs collected by Mr. McAtee at this place and found the contents to consist largely of the finely ground, starchy material from this tuber, in some instances mixed with fibrous bits of stems and roots of other aquatic plants. No animal matter was found. Some of the stomachs contained over 2¼ ounces of food, weighed when moist.

The fact that muskrats swim long distances under the ice is well known, and the generally accepted explanation is the following: When more oxygen is needed the animal comes to the top of the water and exhales its breath against the ice. After waiting a moment for the air bubble to take up oxygen the animal reinhales it and then continues its journey. Thus far, the writer has failed to observe this habit. He has several times watched muskrats swimming under the ice and coming to the surface to breathe, but in every instance he was satisfied that there was air in the space below the ice.

Although the muskrat secures air under the ice, it does not obtain enough to last it while feeding. For this purpose it must reach the outer air. The winter houses are not air-tight, and are used to some extent as dining places; but much of the food is consumed just outside of air holes in the ice, which are kept open by frequent use. Roots, leaves, stems, and grasses are hauled to the surface through these openings; and on these winter "draw-ups" the animals sit while eating. Sometimes the draw-up is roofed over with stems of plants, forming a house large enough to shelter a single muskrat.

In summer the muskrat's menu is far more extensive. It can then choose from many aquatic plants—roots, stems, leaves, and fruit—and in addition can obtain supplies from near-by fields or woods.

Muskrats are fond of nearly all garden vegetables—cabbage, onions, carrots, parsnips, beets, peas, beans, celery, and the like—and they frequently do considerable damage in gardens close to their haunts.

Much of the food collected by the muskrat in summer, whether from land or water, is consumed at the water's edge, while the animal sits on the end of a log, a pile of drift, or a draw-up. The summer draw-up is often quite bulky, showing its long use.

One frequently comes upon heaps of mussel shells, chiefly *Lampsilis* and other *Unionidæ*, on the margins of ponds and streams. The thin-shelled species frequently have the valves broken, but the heavier kinds are often without injury or tooth marks. The inference is that the unbroken mussels have been left to die and open of themselves, after which the muskrat secures the meat.

Hunters occasionally find muskrats feeding on the bodies of waterfowl that have been shot and lost on the marshes. Sometimes a duck is dragged into a muskrat house and devoured there. Muskrats have been known to attack wounded or trapped individuals of their own species, and, like field mice, when hard pressed for food are said to kill and eat the weaker members of their own community.

L. J. Cole and H. C. Tucker, of Ann Arbor, Mich., in 1901–2 kept an adult muskrat in captivity for nearly seven months for the purpose of observing its habits. It refused to eat animal food of any kind, rejecting raw beef, fish, and mussels for its favorite vegetable diet. Carrots were eaten in preference to everything else offered. Besides carrots it ate cabbage, parsnips, potatoes, turnips, corn, bread, cake, nuts (when cracked or shelled), maple bark, crab apple flowers, strawberries, stems of the common flag, and the leaves of a number of kinds of trees.[a] Such observations, while not necessarily indicative of the natural diet, show the animal's preference under the conditions imposed.

DESTRUCTIVE HABITS OF MUSKRATS.

INJURY TO GARDENS AND CROPS.

Damage to crops by muskrats is confined to limited areas. On low-lying lands bordering streams they sometimes attack corn or other grains, the injury usually being restricted to narrow belts near the water's edge. Sometimes growing corn is eaten to the ground, but the damage is greatest when it is in the roasting-ear stage. The animals then cut down the stalks to reach the ears, which they carry to their burrows. Injury to other grains, except rice, is generally slight.

Losses of garden crops on bottom lands are more serious than the losses of grain. The black alluvial soils of creek bottoms are especially adapted to growing vegetables; and to escape the effects of summer drought, the farmer, especially in some of the Western States, often chooses for the vegetable garden a plat near the water. The muskrat frequently invades such plats and destroys the vegetables.

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[a] Fourth Rept. Mich. Acad. Science for 1902, p. 199, 1904.

Mr. Charles Dury, of Cincinnati, Ohio, in a letter to the Biological Survey, dated August 7, 1906, says: "While looking for insects along Duck Creek during June and July, I was greatly surprised at the damage wrought in a cabbage patch, several acres in extent, by muskrats. They had cut off and carried away almost the entire patch, having beaten paths down the bank from the plants to their burrows. The owner of the patch had placed steel traps to catch them, but evidently without success, as the area of destruction was constantly increasing."

Similar reports as to losses of turnips, celery, melons, and other crops are occasionally heard, and also losses of fallen apples when the trees are close to the water.

INJURY TO RICE.

The muskrat is an enemy of the rice planter. More than a half century ago Audubon and Bachman called attention to the fortunate circumstance that this animal was absent from the rice-growing district of the South Atlantic States, remarking that "if it existed in the banks and dikes of the rice fields, it would be a terrible annoyance to the planter, and possibly destroy the reservoirs on which his crop depend."[a]

The same fortunate condition holds for most of the rice districts of the Gulf coast; but in parts of Louisiana—which State has about half the total acreage of rice in the United States—the muskrat is a recognized pest in the plantations. It burrows in the embankments, flooding or draining the fields at the wrong time, and often feeds on the growing crop and breaks down the plants. In Plaquemines Parish planters have for years discouraged the killing of alligators, because the abundance of muskrats is attributed to a scarcity of the saurians, which have been killed for their hides.[b] A law passed by the general assembly of Louisiana in 1908 authorizes the police juries of the several parishes to enact such laws as they deem best to prevent the destruction of alligators.

INJURY TO WATER LILIES.

Where muskrats are abundant they are destructive to water lilies grown in private grounds and public parks. The animals greatly relish the tuberous and highly farinaceous roots of these plants, and often by their depredations make it difficult to establish the lilies in new situations. The common white water lily (*Nymphæa odorata*) is said to be less subject to injury than the odorless species, while the so-called lotus (*Nelumbo*), both native and introduced species, is most frequently injured.

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[a] Quadrupeds of North America, I, 123, 1851.

[b] American Field, XXIV, 176, 1885.

Dr. W. T. Hornaday testifies to the persistence of the muskrat in ornamental ponds, saying: "When three bogs in the New York Zoological Park were dug out and converted into ponds, the wild muskrats in the Bronx River found them as soon as they were completed, immediately took possession of them, and there they still remain. Being very destructive to lily bulbs and most other aquatic plants, their presence in ornamental ponds is very objectionable."[a]

INJURY TO TIDAL MEADOWS.

Along the Atlantic coast are large areas which are overflowed by salt water at highest tides, but which produce useful though coarse grasses. In some of these marshes dikes have been built over the low places to exclude the tides. The quality of the grass is thus improved and cutting by machine is made possible. The embankments have gates to permit the drainage of surface water and to admit the tides when desired. Muskrats often burrow into these dikes and flood the lands at inconvenient times. They attack the tidal gates also and gnaw holes through them, much to the annoyance of the salt-water farmer. While this flooding of meadows results in inconvenience, the losses are not great, and it is highly probable that if properly protected the muskrats would yield better returns to the owners of the land than they now obtain from the hay.

INJURY TO DAMS AND EMBANKMENTS.

The most serious damage done by muskrats is to dams and embankments. Milldams, canals, irrigation ditches, ice ponds, and river levees are more or less subject to injury from these animals. They delight in the deep water afforded by artificial reservoirs. Whenever a canal is built along a river valley, large numbers of muskrats promptly desert the river for the new waterway and pierce the embankments with their burrows. Where the berm bank of the canal is high, little harm is done on that side; but on the other bank and in places where the berm slopes downward, water often penetrates the burrows and disastrous breaks follow. It must be admitted, however, that sometimes the muskrat is blamed for breaks actually caused by crayfish, pocket gophers, moles, and even the common brown rat.

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[a] American Natural History, p. 83, 1904.

Almost every season navigation on some of the principal canals of the country is suspended for a time to repair breaks caused by muskrats. The Delaware and Raritan Canal near Trenton, N. J., was injured by muskrats during the early part of December, 1899, so that the repairs required the complete cessation of navigation for several days. In September, 1894, muskrats caused several enormous breaks in the Erie Canal, one near Rochester and another on the 3-mile level near Brighton.

Injury to rice fields in the South by muskrats has already been mentioned. In the same sections costly levees protect cities and agricultural lands from overflow during freshets. Frequent breaks in these levees occasion heavy losses and much suffering. One of the most common and insidious causes of breaks is the burrows made by muskrats. So serious was the situation in Plaquemines Parish in the winter of 1908–9 that a general slaughter of muskrats took place, and fully half a million of the animals were estimated to have been killed. The pelts netted about $100,000,[a] which in some measure compensated for the losses the animals occasioned to rice and cane.

In irrigated sections of the West, ditches and reservoirs are sometimes injured by muskrats, requiring costly repairs and involving serious delays in the distribution of water to growing crops. Most canal and irrigation companies find it profitable to employ watchmen to patrol the embankments and look for burrows of muskrats, gophers, and other animals.

The breaking of milldams in districts where manufacturers depend on water power is often due to muskrat burrows. Such breaks are a source of loss to manufacturers, operatives, and the entire community. The manufacturer loses in repairs, diminished output, and loss of contracts; the operatives lose their wages; and the community loses in business dependent on the custom of operatives and, not infrequently, in destruction of property. Thus, in the spring of 1904, near Thomaston, Conn., muskrats burrowed through a dam, wrecking it and releasing the water, which injured property in the town to the extent of several thousand dollars.

In April, 1904, the waters of Saline River in southern Illinois invaded the Equality mine and threatened the lives of about a hundred miners. Investigations showed that the waters of the swollen river had reached the mine by way of muskrat burrows.

Instances of the destruction of railway embankments, due to muskrats and water, are not rare. Injury to live stock through stepping into burrows of muskrats is not infrequent; and in one instance a costly driving track which had been constructed near a marsh was abandoned because of continued burrowing beneath it by these animals. A shell road in Dorchester County, Md., was built across an extensive marsh, the superstructure resting on timbers lying on the ground. Muskrats burrowed beneath and made the road unsafe for driving and a constant source of expense to the county for repairs.

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[a] Sport in Dixie, I, No. 2, p. 10, May, 1909.

INJURY TO FISH.

While muskrats sometimes eat fish, they capture sluggish kinds mainly and seldom harm game fish. A few years ago, when German carp were introduced into many parts of this country, it was found that muskrats sometimes invaded ponds and destroyed the carp. This would not now be regarded as a serious loss.

Muskrats cause some loss to the fish culturist by injuring his ponds and possibly by destroying the food of fishes. Mr. James Annin, of the United States Fish Commission, states that the animal, in addition to undermining banks of fish ponds and eating off slats from screens, destroys the caddis worm and other fish food.[a]

ECONOMIC USES OF THE MUSKRAT.

We turn now to a discussion of the economic uses of the muskrat. Its chief value is, of course, for its fur. It is valuable also for its flesh, which is utilized for food.

THE MUSKRAT AS FOOD.

The flesh of the muskrat was generally highly esteemed by the aborigines of North America, especially in winter. The early colonists soon learned to eat the animals, and cooked them in Indian style, boiled with corn. Nearly all professional trappers, hunters, and voyageurs of the North and Northwest considered the flesh palatable, and often ate it roasted over the coals of the camp fire. Featherstonhaugh recorded seeing traders and Indians near Lac qui Parle, Minnesota, drying muskrats for food. He says: "This being the season for muskrats, as the traders call them, they had taken an immense number of them, which they had skinned, and the carcasses, which they are very fond of, were drying on sticks over a slow fire. In twenty days they had taken 1,200 of these animals."[b]

In recent years many persons of refined taste have eaten the flesh of the muskrat and considerable diversity of opinion has been expressed as to its palatability. One writer is emphatic in the opinion that its musky flavor would keep any but the starving from eating it. Another declares that the muskrat is game worthy of an epicure, with a flavor somewhat like the wild duck that has been shot in the same marshes where it has fed.[a] A number of persons have likened its flavor to that of the famous terrapin of the Chesapeake.

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[a] Bul. U. S. Fish Com., IV, 86, 1884.

[b] A Canoe Voyage up the Minnay Sotor, I, 312, 1847.

Sale in the Markets.

The fact remains that muskrats are sold extensively in some of the markets of the East and Middle West. In the retail markets of Philadelphia, Baltimore, Wilmington, and other cities they are sold as "marsh rabbits," but no attempt is made to conceal the fact that they are muskrats. They are bought and eaten both by well-to-do citizens and by the poorer people who seldom indulge in high-priced game. The animals are trapped primarily for their pelts, but after they are skinned, the additional labor of preparing the meat for market is so slight that they can be sold very cheaply.

In the Baltimore markets, February 21, 1908, I found muskrats for sale at various stalls. The retail price was 10 cents each. At the commission houses I learned that several firms receive them regularly from the lower Chesapeake. The muskrat market opens about the Christmas holidays and extends to the middle of March. The receipts for that season had been very light compared with those of the previous year, and the demand had been much greater than the supply. One commission man informed me that he had a standing order for several barrels from one of the smaller towns, but that he could not get enough to supply even the city demand. The wholesale price averaged about 7 cents.

In March, 1909, replies to inquiries at the Baltimore markets showed that during the season then closing a larger supply of muskrats had been received than usual, but, owing to the mild winter, many had arrived in unsalable condition and the wholesale price was lower than for the preceding season.

In February, 1907, the Philadelphia Record stated that a single dealer on Dock street in that city sold about 3,000 muskrats a week for food. The chief source of this supply was stated to be in the vicinity of Salem, N. J. The Saginaw (Mich.) Courier-Herald states that in the season of 1907–8 dressed muskrats at that place retailed at from 15 to 20 cents each, and that dealers had ready sale for all they could provide.

Muskrat is said to be a favorite dish at dinners given by church societies in Delaware and Maryland, and annual muskrat banquets are a feature with certain gun clubs in the West. Those of the Monroe (Mich.) Marsh Club have been celebrated for many years. Nearly a dozen years ago, when the club desired the enactment of a law to protect the muskrat on the marshes adjoining the Great Lakes, they went to Lansing, taking with them their own chefs, and invited the entire legislature to partake of their hospitality. The chief dish was muskrat, but no hint of what they were eating was given the legislators until the banquet was over, when the toastmaster informed the guests that the club desired to have a law passed giving protection to the excellent game of which all had just been partaking, which was muskrat. The law was passed without opposition. Since then invitations to the club's muskrat dinners have been greatly prized.

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[a] Forest and Stream, L, 368, 1898.

Preparing and Cooking.

The flesh of the muskrat is dark red in color but fine grained and tender. Unfavorable opinions as to its flavor arise, probably, from lack of skill in cooking or from carelessness in skinning the animal. In the usual method of skinning, the hair side of the pelts does not come in contact with the flesh, the musk glands often come off with the skin, and only in summer does the musky odor pervade the flesh. An unskilled person is more likely to leave some of the odor, but in winter it may all be removed by washing. The novice should be careful to keep the fur from touching the flesh, to avoid cutting into the musk glands, and to trim off any subcutaneous glands that may adhere to the meat.

The following recipe for cooking muskrat is taken from Forest and Stream:

> Soak the carcass over night in cold water or let it freeze in the open air. Cut in pieces ready to serve and place in a pot with a few slices of salt pork. Add water enough nearly to cover the meat and stew slowly until about dry—say, for an hour and a half. Pepper and salt to taste while cooking.[a]

We are indebted to George T. Bowen, a caterer of 440 West Biddle street, Baltimore, Md., for the following recipes for cooking muskrat:

Fried muskrat.—Wash the muskrat thoroughly and cut in quarters. Let it lie in salt water for an hour or more, then wash, dry with a cloth, and season. Dip the pieces in a prepared egg batter and dust them with flour or meal.

Place the lard in a frying pan and let it get hot. Then put in the muskrat and fry very slowly for an hour. Prepare a gravy of milk, butter, flour, and parsley, and season it to taste. After it thickens pour it over the cooked muskrat.

Roast muskrat.—Wash the meat thoroughly, let it lie for an hour or more in salt water, and then wash again.

Put it in a pan with water, salt, pepper, butter, and a little onion; sprinkle flour over it, and baste it until it is thoroughly done.

Stewed muskrat.—Wash the meat thoroughly, cut it in pieces, and let it lie in salt water for an hour. Then wash again, put it in a sauce pan, and season with butter, salt, and pepper to taste.

Let it simmer slowly, and when nearly done put parsley and a little chopped onion into it. When entirely done thicken with a gravy of flour and water, as for stewed chicken.

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[a] Forest and Stream, L, 368, 1898.

The slightly gamey flavor of muskrats prepared by the above recipes is liked by most persons. Should it be objectionable it may be overcome by soaking the meat overnight in salt water.

MUSKRAT FURS.

In the raw state the fur of the muskrat is dense and soft and in general appearance much like that of the beaver. However, the pelage is shorter and less close and the pelt somewhat inferior in durability. The color varies with season and locality. Northern skins are said to average lightest in color, being often a light silver gray, sometimes nearly white on the underparts. This is probably because many are taken in summer pelage. Very dark skins, classed as black, come mainly from New Jersey, Delaware, and Maryland, but are found in limited numbers in other parts of the United States and in Canada.

Compared with most other furs of such small size, muskrat furs are of excellent quality and durability; their cheapness is chiefly the result of their abundance. The earliest demand for the fur was for the manufacture of so-called beaver hats, it making an excellent imitation. When silk replaced fur in hat manufacture, the demand for muskrat skins fell off greatly. They next became popular as imitations of sealskin. Properly dyed and made up, they are difficult to distinguish from the genuine, but their wearing qualities are greatly inferior. The modern fur dresser and dyer have found means of imitating nearly all the more costly furs with that of this animal, and have thus created a continuous demand for the pelts.

Trade in Muskrat Furs.

The growth of the demand for muskrat furs is shown by the records of London importations and sales. From 1763 to 1800 (thirty-eight years) the total number of skins imported and sold in that market was 2,831,453, an average of less than 75,000 yearly. During the fifty years from 1801 to 1850 the total was 20,571,428, or an average of 411,000 yearly. From 1851 to 1890, inclusive, the importations were 99,893,591, a yearly average of 2,500,000. The average London sales in recent years have been over 4,000,000 per annum, and the entire output of skins for 1900 was 5,285,000.[a] A large part of the total collection is sold through London, but in the last few years an increasing number are dressed and manufactured in America.

Notwithstanding that during the past century and a half nearly a quarter billion of muskrats have been trapped, the supply has not greatly diminished. The total output of 1905, as indicated by London sales of 5,000,000 skins in 1906, was over 7,000,000. The sale of these was accompanied by an advance of 40 per cent in prices. The

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[a] Rept. U. S. Com. Fish and Fisheries for 1902, p. 285, 1904.

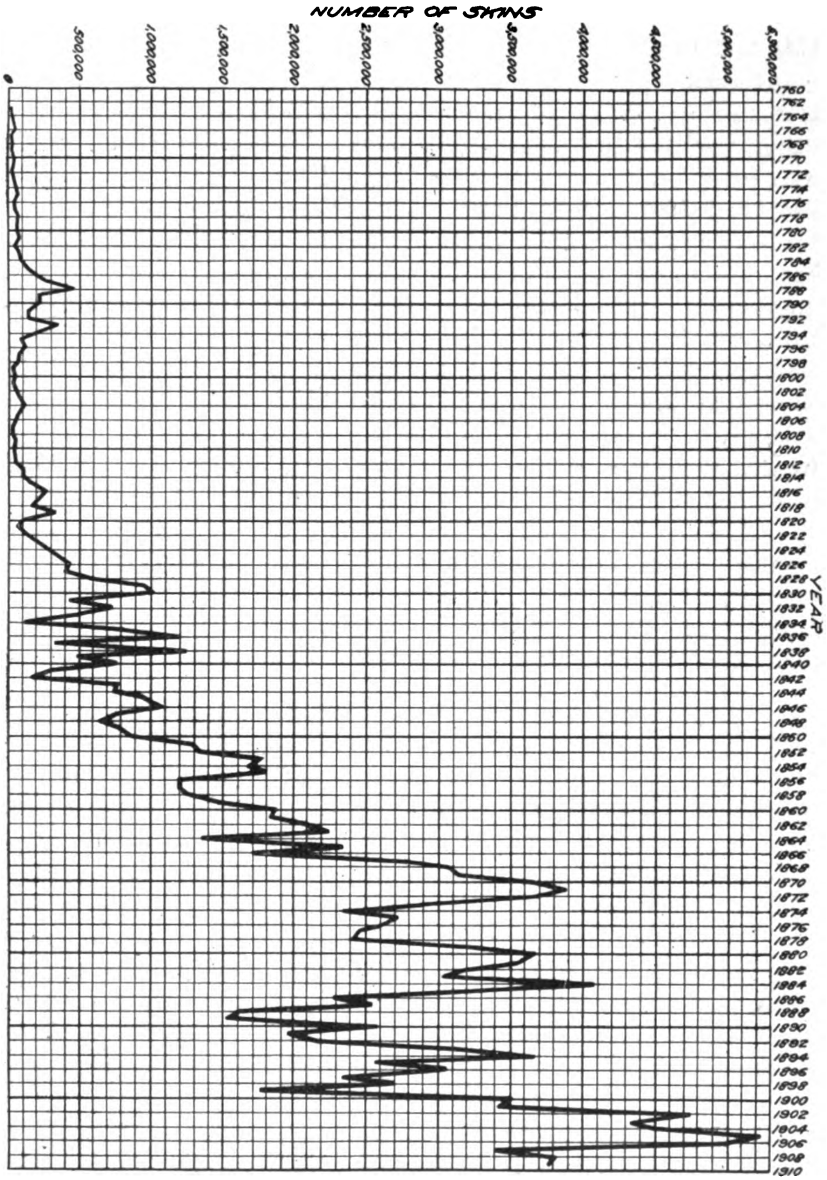

Fig. 3.—Diagram showing number of muskrat skins sold in London each year from 1763 to 1909.

sales for 1907 showed a further advance of about 25 per cent, but a falling off in the offerings of fully 1,500,000 skins. The London sales for 1908 and 1909 showed still further rise in prices, which were again advanced in the January and March sales of 1910. The total London sales for 1908 were 3,806,000; for 1909, 3,771,000. Fig. 3 shows the variation in the numbers of muskrat skins sold in London, 1763 to 1909.[a]

Information from dealers in raw furs in the Chesapeake region indicates that the supply of muskrat furs has been reasonably steady in spite of the prevailing high prices. Baltimore buyers paid 35 cents each for brown and 45 cents for black, ungraded, during the season of 1909. New York buyers offered higher prices, but the furs are graded in that market. On January 22, 1910, Baltimore buyers were paying 65 cents for brown and 70 cents for black skins, ungraded. Trade quotations in The Trapper's World for February, 1910, list No. 1 black muskrat skins at $1 each. Prices are, of course, based on returns from the London auctions and must be low enought to permit a reasonable profit to dealers.

In order to dispose of furs to advantage, trappers should keep informed as to market values. Usually they can realize fair returns by selling to local buyers and at the same time run but slight risk of having the pelts graded too low. There has been much complaint of the practice of dealers in sending out circulars offering high prices for furs to induce shipments. Upon receipt of consignments, however, the furs are so much undergraded that the returns are far less than could have been realized in the local market.

Trapping the Muskrat.

Muskrats are not suspicious and are easily trapped. They take any suitable bait readily, especially in winter and early spring, when green food is scarce. The majority of those captured in the ordinary steel trap are caught by the front leg. A strong trap breaks the leg bone and in struggling the animal is apt to tear loose, leaving a foot, or part of it, in the trap. For this reason the traps should be set so that the captives will quickly drown.

The best baits for muskrat are carrots, sweet apples, parsnips, turnips, or pieces of squash. Many trappers use scent to attract the animals, but it is doubtful if the smell of musk or of any of the oils, as anise or rhodium, has advantages over the natural odor of the baits named.

Most muskrat trappers use the ordinary steel trap (No. 1). The manner of setting it depends upon the situation, and the skill of the trapper is best displayed in selecting this. Muskrat trails may be found along the banks of all streams and ponds which they inhabit, and the practiced eye can often trace them into shallow water. Sink the trap in the trail, partly in the mud or sand where the water is 2 or 3 inches deep, and fasten the chain to a stake, or, better still, to a slender pole reaching into deep water. The pole, upon which the ring of the chain is to slide, should have a fork at the outer end to prevent the ring from slipping farther, and the other end should be stuck firmly into the bank. Fasten the bait to a stick set in the mud, so that the bait is about a foot above the pan of the trap. The animal in reaching for the bait sets the hind foot upon the pan and is caught more securely than if taken by the fore foot. It immediately plunges into deep water, sliding the chain along the pole as far as it will go, and soon drowns. If the chain is fastened to a stake, it should be planted in water a foot or more in depth, so that the animal will drown.

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[a] Statistics are taken from Poland's "Fur-Bearing Animals" and from "Fur Trade Review," 1891 to 1909.

Besides this water set for the steel trap, other situations will suggest themselves to the intelligent trapper. One of the best is in the opening of the animal's burrow in the bank. Here no bait is required. Sometimes a spade is needed to cut out a piece of turf and make room for the trap, the top of which should be at least 2 inches under water.

When ponds are frozen over, traps are often set in the muskrat houses, the trapper going to them on the ice; but this practice destroys the houses and is not to be commended. Trapping near the houses in open water is far better, although it is not always possible to use a boat in the shallow marshes to which the muskrat resorts. When the houses are not far from the bank, a long plank about 5 or 6 inches wide may be used advantageously as a support for traps. It is moored to the shore by a wire passed through a staple driven into one end of the plank, while the other end projects into the pond or rests against the side of the muskrat house. Light cleats are nailed to the upper side of the plank at intervals, with space enough between them to hold a trap when set. The ring at the end of each trap chain is fastened to the plank by a staple. A plank will hold a trap for each foot of its length. Baits of carrot or apple may be scattered along the plank; but they are not necessary, since the animals use such a plank as a highway to reach the shore. An animal venturing upon the plank is almost sure to be caught. In this way most of the occupants of a house may sometimes be taken on one plank in a single night. A floating log, or one extending out into the water, may be used in a similar way as a support for traps. Shallow notches wide enough to hold the traps may be cut into it, and the traps covered lightly with fine leaves or grass.

The box trap is a favorite with some trappers. They use a long wooden box whose cross section inside is about 6 by 6 inches and which has a gate at each end. The gates are of wire and arranged to swing inward but not outward. The box is set just under water with one end at the entrance to a muskrat burrow. The animal lifts the gate on leaving the burrow and is imprisoned and drowned. Others follow until perhaps all the occupants of the burrow are caught. A similar trap may be made entirely of heavy wire netting of half-inch mesh, bent to shape. These traps are well adapted to very narrow streams or ditches.

An open barrel sunk near the bank of the stream or pond frequented by muskrats is said to be an effective trap. The top of the barrel should be level with the surface of the ground. The barrel is half full of water, upon which pieces of carrot or apple are floating. A piece of board about 8 inches square, or a few floating chips, will delude the animals into jumping into the barrel to secure the food.

A floating barrel is said to be a good substitute for a sunken barrel. A hole 8 to 12 inches square is sawed in the side of a barrel having both ends intact. A strong cleat is nailed across each end, projecting 6 or 8 inches on the sides. Upon the projecting cleats boards as long or somewhat longer than the barrel are nailed. Enough water is placed in the barrel to make it float with the outer platform level with the surface of the pond—say, with about one-third of the surface of the barrel exposed (fig. 4). Apples or carrots are placed in the barrel for bait.

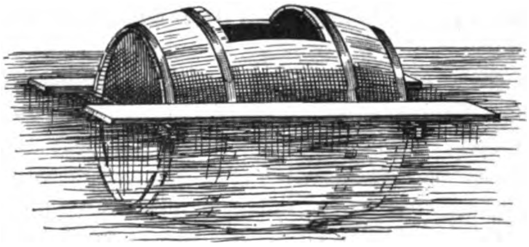

FIG. 4.—Floating muskrat trap.

Another way of taking the muskrat is to spear it inside its winter house. This is a common Indian method; but it should not be encouraged. Not only are the pelts injured by the spear, but when the ponds are ice bound, the animals that escape the spear often perish after their houses are destroyed.

Trapping was at one time a popular calling in the United States; but fur-bearing animals have so decreased in numbers that nowadays few persons earn a livelihood by trapping alone. The business is usually followed for a few weeks or months in winter. A large part of the supply of muskrat fur is taken by boys, who adopt this method of earning a little extra spending money. They often attend school, and look after the traps in the morning and evening. However, on the larger marshes of the country, muskrat trapping has recently become a regular business of considerable importance.

Caring for the Skins.

Muskrats taken for the fur should be trapped—not shot or speared. If taken alive in a trap they should be killed by a sharp blow across the back of the head. Trappers usually carry a short club for this purpose.

Muskrat skins intended for the market should be "cased," not opened along the belly. In skinning, trappers begin at the heel and slit up the middle of the hind leg to the tail, around it, and then down the other leg to the heel in the same way. No other cuts in the skin are needed, though many trappers pass the knife around the feet, where the long fur ends. The skin is then turned back over the body, leaving the fur side inward. The skin peels off easily to the front feet. The trapper cuts closely around nose, ears, and lips, so as not to tear the skin. If bits of flesh adhere to the skin about the head, they may be scraped off, but this is usually left for the fur dresser. The skin, inside out, is stretched over a thin board or a shingle of the proper shape (fig. 5), and a tack or two is inserted to keep it in position until dry. Skins should be dried in the open air—not before a fire or in the sun. They should not be exposed to rain. Books on trapping usually give full directions for caring for raw furs.

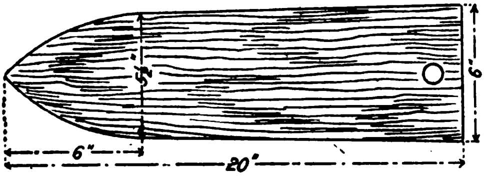

FIG. 5.—Stretcher for muskrat skins.

Home Dressing of Furs.

Formerly many muskrat skins were home tanned and made into caps, collars, and other articles. At present the home utilization of skins is much less extensive, but knowledge of a good method of dressing the fur is still desirable. Most of the methods employed by amateurs involve the use of alum to fix the hair; but satisfactory results, so far as pliability of the pelts goes, depend largely upon the amount of labor bestowed on them.

A method in common use is the following: The skins are thoroughly cleaned in warm, not hot, water and all flesh and fat scraped off. They are then stretched on a board with the fur side down and covered with a mixture of two ounces each of salt and alum, 3 gills of water, and a drachm of sulphuric acid. Thicken this with wheat bran or flour and allow it to dry on the skin. When dry, the flour or bran should be scraped off, the skin removed from the board and rolled with the fur side in. The folded skin is then drawn quickly many times through an iron ring. It should be unfolded at intervals and rerolled in another direction. This is continued until the entire skin is soft and flexible.

The following method was recommended by the late William Hamilton Gibson:

> The skin should always be thoroughly cleaned in warm water and all fat and superfluous flesh removed. It should then be immersed in a solution made of the following ingredients: Five gallons of cold soft water, 5 quarts wheat bran, 1 gill of salt, and 1 ounce of sulphuric acid. Allow the skin to soak in the liquid for four or five hours. If the hides have been previously salted, the salt should be excluded from the mixed solution. The skins are now ready for the tanning liquor, which is made in the following way: Into 5 gallons of warm soft water stir 1 peck of wheat bran and allow the mixture to stand in a warm room until fermentation takes place. Then add 3 pints of salt and stir until it is thoroughly dissolved. A pint of sulphuric acid should then be poured in gradually, after which the liquor is ready. Immerse the skins and let them soak for three or four hours. The process of fleshing follows. This consists of laying the skin, fur side down, over a smooth beam and working over the flesh side with a blunt fleshing tool. An old chopping knife or a tin candlestick forms an excellent substitute for the ordinary fleshing knife, and the process of rubbing should be continued until the skin becomes dry, when it will be found to be soft and pliable.[a]

Dressing for the Manufacturer.

Many of the muskrat skins used by American manufacturers of fur garments are now dressed in the United States. Formerly nearly all were dressed in Europe and came back to the United States largely as manufactured furs, dyed to imitate the pelts of other animals. Great improvements in the process of dressing the skins have been made in this country, as is shown by comparison of those dressed here in the natural color with the plucked and dyed skins commonly returned from abroad. Yet it must be confessed that the back strips taken from winter and spring muskrats are made into garments that very closely resemble those of fur seal. After the cased raw skins are bought in London, many are split into back and belly strips, and the backs, plucked and dyed a rich seal brown, are resold to fur manufacturers at the Leipzig sales.

The operation of dressing muskrat skins is rather complicated, and to the uninitiated the various processes seem needlessly numerous. The following is abridged from an account written by Mr. Charles H. Stevenson:[b]

> At the fur dresser's the skins are first dampened on the flesh side with salt water and left all night to soften. The following morning they are placed in

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[a] Camp Life and the Tricks of Trapping, p. 227, 1881.

[b] Report of Commission of Fish and Fisheries for 1902, p. 315, 1904.

a tramping machine, where they are tramped for eight or ten hours. The machine works about 2,000 pelts at a time.

The pelts are next covered with a mixture of sawdust and salt water and remain so overnight. The following morning they are cut open down the front and are then fleshed, one man being able to flesh 200 to 300 in a day. The skins are next stretched and hung up to dry. When thoroughly dry, they are again moistened with salt water on the leather side, remaining so overnight. They are next brushed on the flesh side with animal fat—butter or fish oil and tallow—and laid in pairs with the fur side out. After remaining overnight they are placed in tramping machines and worked for six or eight hours, or until thoroughly soft and pliable. They are then stretched in every direction.

The next process is cleaning. The skins to the number of 300 or 400 are placed with sawdust in revolving drums exposed to steam heat. They are revolved for about three hours, when the sawdust will have completely absorbed the grease. The skins are next incased in a beating drum, where they are revolved for two or three hours. On removal they are beaten with rattans and the fur is cleaned with a comb. The heavier pelts are fleshed down thin, thus completing the operation of dressing for the majority of skins. A small percentage are plucked or perhaps dyed. In either case they have to be cleaned once more before the process is complete.

Manufactures of Muskrat Furs.

Besides the considerable use of muskrat skins for manufacture into garments in imitation of high-grade furs, a good proportion of the poorer skins are used in the natural color for lining overcoats and other outer garments. One cause for the increased demand for fur linings is the great influx of settlers into the Northwestern States, Canada, and Alaska, where in winter the warmest garments are absolutely necessary. Garments made from skins of wolves, goats, or dogs partly supply this need, but cloth outer garments with linings of light furs are fully as warm and are less burdensome. The growing popularity of the automobile for outdoor recreation in winter is another cause for the increased demand for fur-lined coats.

The better grades of muskrat furs, dressed in the natural color, have a beautiful luster, and make really handsome coats, boas, and muffs; and many smaller articles of apparel, as collars, gloves, caps, and the like, are made of muskrat fur.

MUSKRAT FARMING.

Fur farming has been a favorite topic for discussion in American newspapers. While many fur-producing enterprises have been planned and some actually begun, few have prospered. Various difficulties have discouraged the majority of persons who have engaged in raising minks, foxes, or skunks. However, the possibilities of such enterprises have not really been tested, and present prices for these furs might well repay investment of capital in their production.

Until recently the price of muskrat fur has not been high enough to warrant expenditures on preserves, or even efforts to prevent poaching. With present conditions, carefully guarded preserves will yield steady and profitable returns. All that is needed is care not to deplete the fur supply by too close trapping.

Some Examples.

Muskrat farming is already a prosperous business. The Cedar Point Hunting Club, of Toledo, Ohio, controls 5,000 acres of marsh at the mouth of the Maumee River, near Lake Erie. In the winter of 1903–4, after the muskrats had been undisturbed for two years, they were trapped for the benefit of the club. Five thousand were taken in a single month (January, 1904), and the skins were sold for 25 cents each. The carcasses also were sold at a dollar a dozen.[a]

The muskrat industry has probably reached its highest present development on the eastern shore of Maryland. The extensive marshes of Dorchester County are a center of muskrat fur production, and the writer recently visited that section to learn about this industry.

Formerly the owners of marshes in this vicinity paid little attention to them. The land was considered useless because subject to tidal overflow. Trappers were allowed to take muskrats wherever they chose, and a dozen years ago much of the marsh land could have been bought for less than 50 cents an acre. At the present time some of the marshes are worth more, measured by the actual income from them, than cultivated farms of like acreage in the same vicinity. The increased values are due to the muskrat. Landowners now usually lease the trapping privilege, and trappers and owners unite to protect the marshes from poaching. The owner receives half the fur caught, while the trapper gets the other half and all he can realize from the sale of the meat. In the short season of seventy-four days, January 1 to March 15, during the last two years, trappers have easily made from $400 to $900 each.

A few specific examples will give a better idea of the value of these marsh lands. The owner of one tract of marsh informed the writer that he bought it three or four years ago for $2,700. It is leased for half the fur, and yielded him in 1909 $890, or about 33 per cent on the investment. The owner of a small piece of marsh—about 40 acres—bought it in 1905 for $150. Leased for half the fur, it has yielded the owner $30, $60, $70, and $100, respectively, for each of the four years, 1906 to 1909. Taxes are very light, and on the basis of a 6 per cent income the returns for 1909 would represent an approximate value of nearly $40 an acre for this land. The owner of a 1,300-acre tract of marsh trapped it this season, with the aid of his sons, and secured over 5,000 muskrats, which were sold for $2,300.

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[a] Fur Trade Review, p. 96, February, 1904.

The furs sold in this region are seldom assorted before sale. They are separated into black and brown and then counted, a deduction of from 3 to 5 per cent being made for "kitts." The skins sold throughout the present season at Baltimore prices, 35 cents for brown and 45 cents for black. The proportion of black skins varies on the different marshes from 10 to 60 per cent, the average being about 40 per cent.

The muskrat meat is an additional source of income to the trapper. It is bought by local buyers, who during the season 1909 paid only 4 cents for each animal; it is shipped to outside markets or sold for local consumption. The demand for the meat is growing, and all of it is utilized. The Baltimore market takes about 30,000 animals during a season, the bulk of which come from Dorchester County.

The editor of the Cambridge Record, a local newspaper, stated that the muskrat industry of Dorchester brings into the county about $100,000 annually. This would indicate that about a quarter million of the animals are trapped each season. The danger of exhausting the supply by continued close trapping has been discussed in Dorchester County, but trappers maintain that with the long closed season, March 15 to January 1, little ground for anxiety on this score exists.

Possibilities of the Business.

Muskrats require no feeding, since the plant life of ponds and marshes furnishes abundance of food. In many States the areas adapted to the muskrat are extensive, and doubtless the animals could be profitably introduced into sections from which they are now absent. As trapping is done in winter, the business of muskrat farming is peculiarly adapted to farmers and farmers' boys.

The improvement of the muskrat's pelage by selective breeding has never been attempted. Probably the black muskrat could be bred true to color and greatly improved in the localities it now inhabits, and could be successfully introduced into other sections of the country. Indeed, to make the most of the muskrat industry requires that the possibilities of selective breeding be tested.

THE MUSKRAT AS A PEST.

Its destructive habits make the muskrat a pest in comparatively few places. On the whole, and especially in large marshes and uninhabited sections, its economic value far outweighs the harm it does. On many of the streams it inhabits, no attempts have been made to impound water for use, and hence the animal does not interfere with engineering operations. In all such situations and in swamps the animal should have ample protection to insure a present and future fur supply. The present value of the pelt is an incentive to excessive trapping.

MEANS OF DESTRUCTION.

Mill owners and superintendents of canals, irrigation works, and levees are sometimes confronted with the necessity for active operations against muskrats, and should know the more effective methods of fighting them. It must be confessed that the usual means have not been very successful. Rewards for killing them have never effected more than a temporary reduction of their numbers. Shooting ordinarily makes the survivors exceedingly wary. While trapping is more successful, it can seldom be carried to the limit of practical extermination.

Methods of trapping are effective in both summer and winter, but when green food is abundant greater care is needed in the selection of baits. With enough steel traps placed in favorable locations the danger to embankments may be greatly diminished. The barrel trap will sometimes bring quicker relief, since it often captures an entire family of muskrats at one setting. Whenever possible, trapping these animals should be deferred until their skins are prime.

Although muskrats are hard to poison, they can be destroyed more rapidly by poisoning than by trapping. Strychnine is usually preferable to other poisons. Powdered strychnia sulphate sweetened with powdered sugar or commercial saccharin and sprinkled over freshly cut pieces of apple, carrot, or ripe squash has proved effective in many cases. Crystals of the same poison inserted in the baits with a knife have also given good results. Care must be taken to keep poisoned baits where they will not endanger other valuable wild or domestic animals.

PROTECTING PROPERTY FROM MUSKRATS.

The use of concrete foundations of proper depth for dams reduces to a minimum the danger of injury from muskrats.

Probably the most successful means of protecting earthen embankments is to employ a skillful trapper to patrol them regularly, using traps, poisons, and a small caliber rifle. The patrol is usually charged with the additional duty of watching for and promptly repairing slight breaks in the embankments.

Several methods of keeping muskrats from injuring small ponds have been recommended. One is the liberal use of gravel or coarse sand for the surface of embankments, since the animals will not burrow in soil that fills the hole as fast as they open it.

The best means of protecting the vegetable garden from muskrats is to erect a fence of netting, either surrounding the garden or skirting the bank of the stream or pond. The netting should be of galvanized wire 3 feet or more in width and of an inch and a half mesh. The lower edge should be sunk 6 inches into the soil to prevent the animals from digging under.

ENEMIES OF THE MUSKRAT.

Man is by no means the only destroyer of the muskrat. Among its natural enemies are the coyote, fox, mink, the larger hawks and owls, and the pickerel. But all of these enemies together do not greatly affect the number of muskrats.

Next to trapping, floods and droughts destroy the largest numbers. Richardson was the first to record the effect of the elements on the muskrat. He states that inundations destroy many and that in parts of the country severe winters extirpate them by freezing the swamps and shallow ponds solid and that then they die of famine or destroy each other. Also they die in large numbers from some unknown cause. Sometimes the decrease is so great that fur posts have to be abandoned.[a]

R. MacFarlane says that seasons of high water favor the propagation of the muskrat, while summers of drought and continued low-water limit increase and also cause much mortality during the succeeding winter. He adds that in some years many thousands of the animals perish miserably under the ice and in their frozen up "washes" or winter homes; also that many die of disease.[b] MacFarlane cites these facts in explanation of the great fluctuation in the number of muskrat skins collected from year to year in northwest Canada. However, the prolific breeding of the animals during one or two favorable seasons usually restores the normal numbers.

The proposed reclamation of swamps and marsh lands throughout the country, if carried out, will greatly reduce the number of muskrats by restricting their habitat; and if the supply of this fur is to be maintained, it must be through protection and eventually through private ownership.

PROTECTIVE LAWS.

From an economic point of view the protection of fur-bearing animals is just as important as the preservation of game; but, until recently, laws for their protection have been few. A number of

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[a] Fauna Boreali-Americana, p. 117, 1829.

[b] Proc. U. S. Nat. Mus., XXVIII, 737, 1905.

States now protect the beaver absolutely, but in most of them the laws came too late to accomplish much good. A majority of the Northern States now have a closed season for certain fur bearers, and in some of them the muskrat is specifically included; but in most parts of the United States inhabited by this animal it may be killed at any time and in any manner.

CLOSED SEASONS.

Nearly all the Canadian provinces protect the muskrat by a closed season. These include Alberta, Manitoba, New Brunswick (certain counties), Nova Scotia, Ontario, Quebec, Prince Edward Island, and Saskatchewan. In the United States 13 States have laws affording partial protection to the muskrat, as follows:

Delaware.—The closed season for muskrats is March 20 to December 1. Muskrats may not be hunted by use of lights at night, nor in Kent County during freshets that drive them from their usual abodes.

Illinois.—No fur-bearing animals may be captured for profit between May 1 and November 1.

Iowa.—Muskrats are protected from April 1 to November 1, except when found damaging private or public property.

Maine.—The closed season on muskrats extends from May 1 to October 15, but a few towns have special laws relating to these animals. The legislature of 1909 changed the opening date for trapping muskrats from December 1 to October 15, a change that no consideration can justify.

Maryland.—Closed season April 1 to January 1. Seven counties have different closed seasons as noted below. Ten counties have no protection for muskrats.

Anne Arundel County.—The closed season for muskrats is from March 1 to December 1. It is unlawful to destroy muskrat dens or houses.

Caroline County.—Closed season April 1 to December 15.

Dorchester County.—Closed season March 15 to January 1. It is unlawful to use artificial light in taking these animals.

Kent County.—It is unlawful to use light in hunting muskrats.

Somerset County.—Closed season March 15 to December 15. Unlawful at all times to shoot muskrats.

Talbot County.—Closed season March 15 to December 1.

Wicomico County.—Closed season March 15 to December 15.

Patuxent River marshes.—Muskrats may not be shot from two hours after sunset to one hour before sunrise.

Michigan.—Muskrats may not be killed from April 15 to October 31, both dates included. It is unlawful to destroy muskrat houses at any time or to set traps within 6 feet of a muskrat house. The owner of property may destroy the animals on his own premises when it can be shown that they are doing damage.

Minnesota.—Muskrats are protected April 15 to November 15. Muskrat houses are protected at all times. The animals may be killed at any time by the owner of property injured by them.

New Jersey.—Muskrats may not be killed April 1 to December 1, except on embankments or on lands protected from overflow by embankments. This law was passed January 21, 1829.

New York.—The closed season for muskrats is May 1 to October 15. They shall not be possessed or killed during this time.

North Carolina: *Columbus County.*—All fur-bearing animals are protected April 1 to January 1, except that two townships have closed season March 1 to December 1.

Currituck Sound.—It is unlawful to shoot muskrats on marsh lands on the east side of Currituck Sound after sundown or before sunrise between October 1 and March 31.

South Dakota.—Muskrats are protected April 1 to November 15, except when they destroy property. Town supervisors may employ others to kill or trap muskrats to protect public highways. Trappers not residents of the State must take out a license before trapping; fee $10.

Virginia.—Shooting muskrats by night is unlawful in tidewater districts of the State.

Accomac County.—Muskrats are protected March 15 to January 1.

Wisconsin.—Muskrats may not be taken by spear or gun. The closed season extends from May 1 to November 1. Occupants or owners of lands on the shores of certain rivers and lakes may take muskrats in any manner from October 25 to May 1, but may not dispose of pelts before the general open season. Owners of cranberry marshes are allowed to kill the animals at any time when they are destroying dams.

Previous to the passage of the present law, a prominent fur buyer of Michigan estimated that the trappers of that State would be benefited $100,000 a year by the passage of a law prohibiting the taking of fur in September and October.[a] The muskrat pelt taken in October or November is worth scarcely half as much as if trapped in February. Trappers are still careless of their own interests, and in their eagerness to forestall competitors take the field far too early. Fur dealers, on the other hand, have generally deprecated this policy, and have endeavored to secure reform. A prominent firm, extensive buyers of raw furs, in 1904 sent out a circular asking for cooperation to secure laws protecting all fur-bearing animals from May 1 to November 1. While the movement is in the right direction, it would not, if carried out, prove adequate to correct all the evils of unseasonable trapping. Muskrats within the United States should not be trapped before December 15; and while the fur is still prime in the latter part of March, the breeding season is then on, and continued trapping would greatly limit the number of animals for the next season. The open season for the muskrat should be limited to three months, from December 15 to March 15, or in the more northern States from December 1 to March 1.

SUMMARY.

Muskrats are of much economic value, and should be protected by proper laws. Legal enactments should forbid their destruction during the reproducing season and whenever their furs are not prime. Spearing and shooting should be prohibited. Muskrat houses should be protected at all times. The trapping season should be nearly uniform for the different States.

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[a] Fur Trade Review, p. 118, March 1, 1895.

Protective laws should contain provisions allowing corporations and individuals whose property is being damaged by muskrats to destroy the animals in the closed season under the supervision of game wardens or other officers, but not for profit.

If properly protected the muskrat will continue to inhabit our rivers and ponds for an indefinite period, and to furnish a stock of furs for our own and future generations.

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. *Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them.* Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 397.

BEES.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology.
Washington, D. C., March 8, 1910.

Sir: I have the honor to transmit herewith a manuscript entitled "Bees," by E. F. Phillips, Ph. D., in charge of bee culture in this Bureau. In the preparation of this paper, which is intended to supersede Farmers' Bulletin No. 59, the aim has been to give briefly such information as is needed by persons engaged in the keeping of bees, and to answer inquiries such as are frequently received from correspondents of the Department. No attempt has been made to include discussions of bee anatomy, honey plants, or the more special manipulations sometimes practiced, such as queen rearing. The discussion of apparatus is necessarily brief. I respectfully recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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BEES.

INTRODUCTION.

Bee keeping for pleasure and profit is carried on by many thousands of people in all parts of the United States. As a rule, it is not the sole occupation. There are, however, many places where an experienced bee keeper can make a good living by devoting his entire time and attention to this line of work. It should be emphasized that it is unwise for the average individual to undertake extensive bee keeping without considerable previous experience on a small scale, since there are so many minor details which go to make up success in the work. These must be thoroughly understood before there is any hope for continued success. It is, therefore, most desirable to begin on a small scale, make the bees pay for themselves and for all additional apparatus, as well as some profit, and gradually to increase as far as the local conditions or the desires of the individual permit.

Bee culture is the means of obtaining for human use a natural product which is abundant in almost all parts of the country, and which would be lost to us were it not for the honey bee. The annual production of honey and wax in the United States makes apiculture a profitable minor industry of the country. From its very nature it can never become one of the leading agricultural pursuits, but that there is abundant opportunity for its growth can not be doubted. Not only is the honey bee valuable as a producer, but it is also one of the most beneficial of insects in cross-pollinating the flowers of various economic plants.

Bee keeping is also extremely fascinating to the majority of people as a pastime, furnishing outdoor exercise as well as intimacy with an insect whose activity has been a subject of absorbing study from the earliest times. It has the advantage of being a recreation which pays its own way and often produces no mean profit.

It is a mistake, however, to paint only the bright side of the picture and leave it to the new bee keeper to discover that there is often another side. Where any financial profit is derived, bee keeping requires hard work and work at just the proper time, otherwise the surplus of honey may be diminished or lost. Few lines of work require more study to insure success. In years when the available nectar is limited, surplus honey is secured only by judicious manipulations and it is only through considerable experience and often by expensive reverses that the bee keeper is able to manipulate properly to save his crop. Anyone can produce honey in seasons of plenty, but these do not come every year in most locations and it takes a good bee keeper to make the most of poor years. When, even with the best of manipulations, the crop is a failure through lack of nectar, the bees must be fed to keep them from starvation.

The average annual honey yield per colony for the entire country, under good management, will probably be 25 to 30 pounds of comb honey or 40 to 50 pounds of extracted honey. The money return to be obtained from the crop depends entirely on the market and the method of selling the honey. If sold direct to the consumer, extracted honey brings from 10 to 20 cents per pound, and comb honey from 15 to 25 cents per section. If sold to dealers, the price varies from 6 to 10 cents for extracted honey and from 10 to 15 cents for comb honey. All of these estimates depend largely on the quality and neatness of the product. From the gross return must be deducted from 50 cents to $1 per colony for expenses other than labor, including foundation, sections, occasional new frames and hives, and other incidentals—not, however, providing for increase.

Above all it should be emphasized that the only way to make bee keeping a profitable business is to produce only a first-class article. We can not control what the bees bring to the hive to any great extent, but by proper manipulations we can get them to produce fancy comb honey, or if extracted honey is produced it can be carefully cared for and neatly packed to appeal to the fancy trade. Too many bee keepers, in fact the majority, pay too little attention to making their goods attractive. They should recognize the fact that of two jars of honey, one in an ordinary fruit jar or tin can with a poorly printed label, and the other in neat glass jar of artistic design with a pleasing, attractive label, the latter will bring double or more the extra cost of the better package. It is perhaps unfortunate, but nevertheless a fact, that honey sells largely on appearance, and a progressive bee keeper will appeal as strongly as possible to the eye of his customer.

LOCATION OF THE APIARY.

The location of the hives is a matter of considerable importance. As a rule it is better for hives to face away from the prevailing wind and to be protected from high winds. In the North, a south slope is desirable. It is advisable for hives to be so placed that the sun will strike them early in the morning, so that the bees become active early in the day, and thus gain an advantage by getting the first supply of nectar. It is also advantageous to have the hives shaded during the hottest part of the day, so that the bees will not hang out in front of the hive instead of working. They should be so placed that the bees will not prove a nuisance to passers-by or disturb livestock. This latter precaution may save the bee keeper considerable trouble, for bees sometimes prove dangerous, especially to horses.

The plot on which the hives are placed should be kept free from weeds, especially in front of the entrances. The hives should be far enough apart to permit of free manipulation. If hives are too close together there is danger of bees entering the wrong hive on returning, especially in the spring.

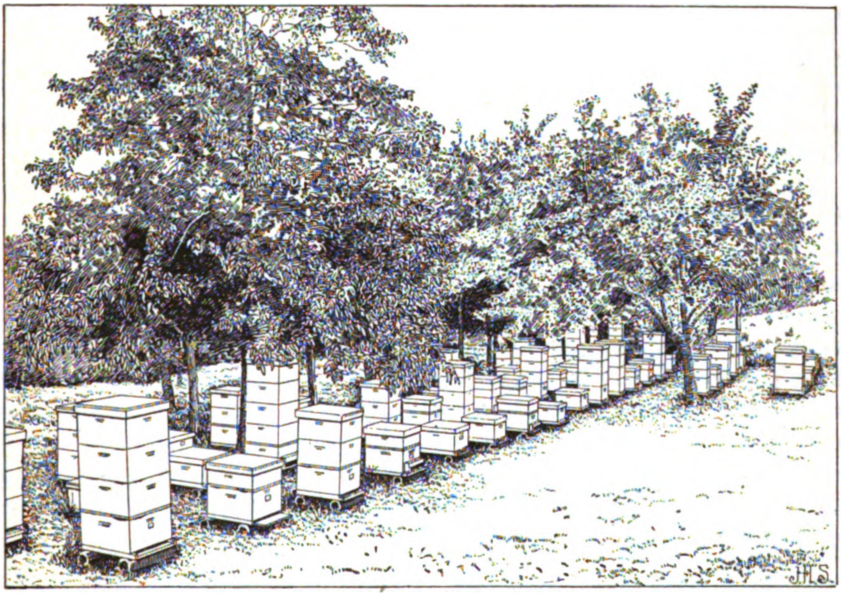

FIG. 1.—A well-arranged apiary.

These conditions, which may be considered as ideal, need not all be followed. When necessary bees may be kept on house tops, in the back part of city lots, in the woods, or in many other places where the ideal conditions are not found. As a matter of fact, few apiaries are perfectly located; nevertheless, the location should be carefully planned, especially when a large number of colonies are kept primarily for profit.

As a rule, it is not considered best to keep more than 100 colonies in one apiary, and apiaries should be at least 2 miles apart. There are so many factors to be considered, however, that no general rule can be laid down. The only way to learn how many colonies any given locality will sustain is to study the honey flora and the record of that place until the bee keeper can decide for himself the best number to be kept and where they shall be placed.

The experience of a relatively small number of good bee keepers in keeping unusually large apiaries indicates that the capabilities of the average locality are usually underestimated. The determination of the size of extensive apiaries is worthy of considerable study, for it is obviously desirable to keep bees in as few places as possible, to save time in going to them and also expense in duplicated apparatus. To the majority of bee keepers this problem is not important, for most persons keep but a small number of colonies. This is perhaps a misfortune to the industry as a whole, for with fewer apiaries of larger size under the management of careful, trained bee keepers the honey production of the country would be marvelously increased. For this reason, professional bee keepers are not favorably inclined to the making of thousands of amateurs, who often spoil a location for a honey producer and more often spoil his market by the injudicious selling of honey for less than it is worth or by putting on the market an inferior article.

Out apiaries, or those located away from the main apiary, should be so located that transportation will be as easy as possible. The primary consideration, however, must be the available nectar supply and the number of colonies of bees already near enough to draw on the resources. The out apiary should also be near to some friendly person, so that it may be protected against depredation and so that the owner may be notified if anything goes wrong. It is especially desirable to have it in the partial care of some person who can hive swarms or do other similar things that may arise in an emergency. The terms under which the apiary is placed on land belonging to some one else is a matter for mutual agreement. There is no general usage in this regard.

EQUIPMENT IN APPARATUS.

It must be insisted that the only profitable way to keep bees is in hives with movable frames. The bees build their combs in these frames, which can then be manipulated by the bee keeper as necessary. The keeping of bees in boxes, hollow logs, or straw "skeps" is not profitable, is often a menace to progressive bee keepers, and should be strongly condemned. Bees in box hives (plain boxes with no frames and with combs built at the will of the bees) are too often seen in all parts of the country. The owners may obtain from them a few pounds of inferior honey a year and carelessly continue in the antiquated practice. In some cases this type of bee keeping does little harm to others, but where diseases of the brood are present the box hive is a serious nuisance and should be abolished.

HIVES.

It is not the purpose of this bulletin to advocate the use of any particular make of hive or other apparatus. Some general statements may be made, however, which may help the beginner in his choice.

The type of hive most generally used in this country (fig. 2) was invented by Langstroth in 1851. It consists of a plain wooden box holding frames hung from a rabbet at the top and not touching the sides, top, or bottom. Hives of this type are made to hold from eight frames upward. The size of frame in general use, known as the Langstroth (or L) frame (9⅛ by 17⅝ inches), is more widely used than all others combined. The number of frames used depends on the kind of honey produced (whether comb or extracted), and on the length of honey flow and other local factors. There are other hives used which have points of superiority. These will be found discussed in the various books on bee keeping and in the catalogues of dealers in bee keepers' supplies.

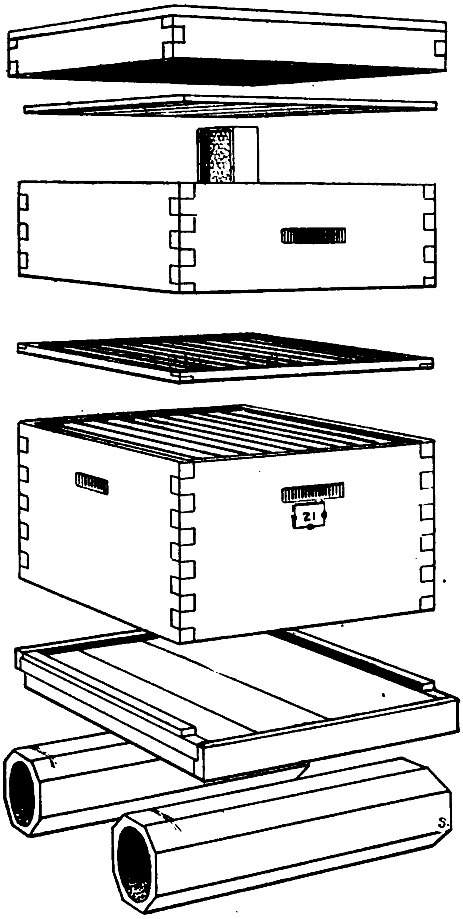

FIG. 2.—A ten-frame hive with comb-honey super and perforated zinc queen excluder.

Whatever hive is chosen, there are certain points of importance which should be insisted on. The material should be of the best; the parts must be accurately made, so that all frames or hives in the apiary are interchangeable. All hives should be of the same style and size; they should be as simple as it is possible to make them to facilitate operation. Simple frames diminish the amount of propolis, which will interfere with manipulation. As a rule, it is better to buy hives and frames from a manufacturer of such goods rather than to try to make them, unless one is a good wood worker.

The choice of a hive, while important, is usually given undue prominence in books on bees. In actual practice experienced bee keepers with different sizes and makes of hives under similar conditions do not find as much difference in their honey crop as one would be led to believe from the various published accounts.

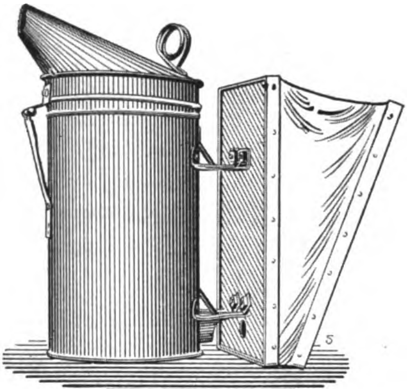

FIG. 3.—Smoker.

HIVE STANDS.

Generally it is best to have each hive on a separate stand. The entrance should be lower than any other part of the hive. Stands of wood, bricks, tile (fig. 2), concrete blocks, or any other convenient material will answer the purpose. The hive should be raised above the ground so that the bottom will not rot. It is usually not necessary to raise the hive more than a few inches. Where ants are a nuisance special hive stands are sometimes necessary.

OTHER APPARATUS.

In addition to the hives in which the bees are kept some other apparatus is necessary. A good smoker (fig. 3), consisting of a tin or copper receptacle to hold burning rotten wood or other material, with a bellows attached, is indispensable. A veil of black material, preferably with a silk tulle front (fig. 4), should be used. Wire-cloth veils are also excellent. Even if a veil is not always used, it is desirable to have one at hand in case the bees become cross. Cloth or leather gloves are sometimes used to protect the hands, but they hinder most manipulations. Some sort of tool (fig. 5) to pry hive covers loose and frames apart is desirable. A screw-driver will answer, but any of the tools made especially for that purpose is perhaps

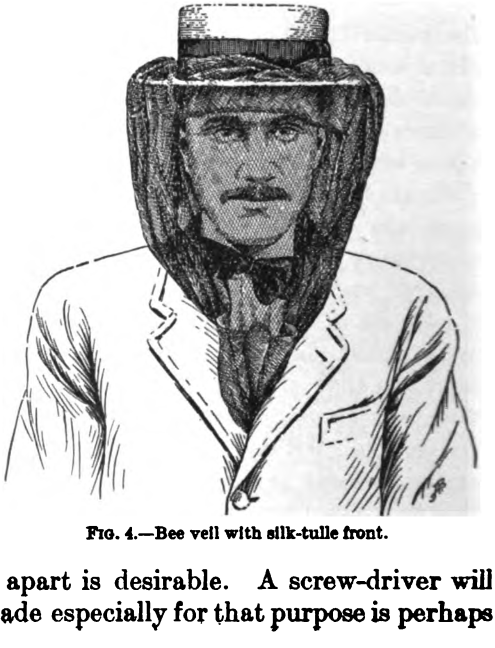

FIG. 4.—Bee veil with silk-tulle front.

better. Division boards, drone traps (fig. 6), bee escapes (figs. 7 and 8), feeders (figs. 14, 15, 16, 17), foundation fasteners, wax extractors, bee brushes (fig. 9), queen-rearing outfits, and apparatus for producing comb or extracted honey (figs. 2, 18, 19) will be found described in catalogues of supplies; a full discussion of these implements would require too much space in this bulletin. A few of these things are illustrated, and their use will be evident to the bee keeper. It should be remembered that manipulation based on a knowledge of bee activity is of far greater importance than any particular style of apparatus, and in a short discussion like the present it should be given more space, especially since supply dealers will be glad to furnish whatever information is desired concerning apparatus.

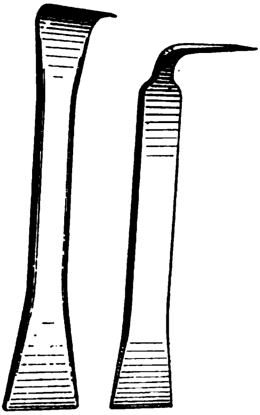
FIG. 5.—Hive tools.

EQUIPMENT IN BEES.

As stated previously, it is desirable to begin bee keeping with a small number of colonies. In purchasing these, it is usually best to obtain them near at home rather than to send to a distance, for there is considerable liability of loss in shipment. Whenever possible, it will be better to get bees already domiciled in the particular hive chosen by the bee keeper as the best, but if this is not practicable then bees in any hives or in box hives may be purchased and transferred. It is a matter of small importance what race of bees is purchased, for queens of any race may be obtained and introduced in place of the original queen, and in a short time the workers will all be of the same race as the introduced queen. This is due to the fact that during the season worker bees die rapidly, and after requeening they are replaced by the offspring of the new queen.

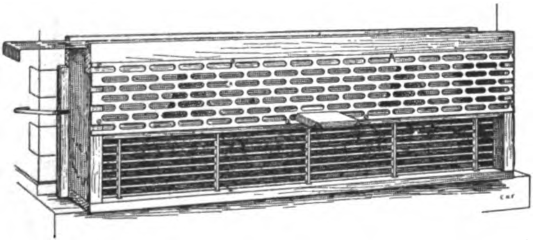
FIG. 6.—Drone and queen trap on hive entrance.

A most important consideration in purchasing colonies of bees is to see to it that they are free from disease. In many States and counties there are inspectors of apiaries who can be consulted on this point, but if this is not possible even a novice can tell whether or not there is anything wrong with the brood, and it is always safest to refuse hives containing dead brood.

The best time of the year to begin bee keeping is in the spring, for during the first few months of ownership the bee keeper can study the subject and learn what to do, so that he is not so likely to make a mistake which will end in loss of bees. It is usually best to buy good strong colonies with plenty of brood for that season of the year, but if this is not practicable, then smaller colonies, or nuclei, may be purchased and built up during the season. Of course, no surplus honey can be expected if all the honey gathered goes into the making of additional bees. It is desirable to get as little drone comb as possible and a good supply of honey in the colonies purchased.

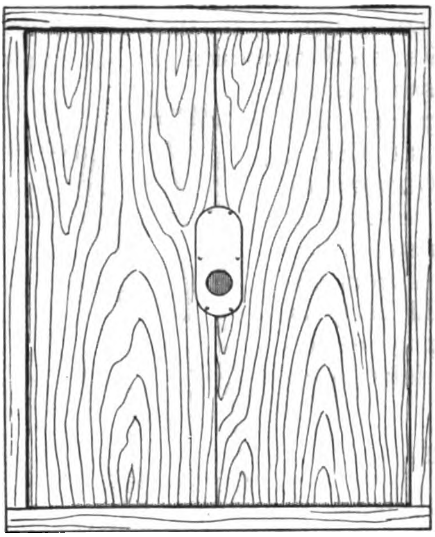
Fig. 7.—Bee escape for removing bees from supers.

The question as to what race and strain of bees is to be kept is important. If poor stock has been purchased locally, the bee keeper should send to some reliable queen breeder for good queens as a foundation for his apiary. Queens may be purchased for $1 each for "untested" to several dollars each for "selected" breeding queens. Usually it will not pay beginners to buy "selected" breeding queens, for they are not yet prepared to make the best use of such stock. "Untested" or "tested" queens are usually as good a quality as are profitable for a year or so, and there is also less danger in mailing "untested" (young) queens.

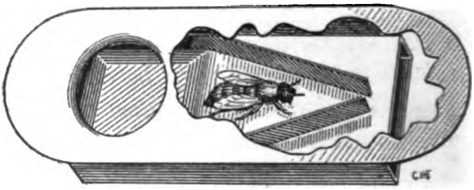

Fig. 8.—Spring bee escape.

Various races of bees have been imported into the United States and among experienced bee keepers there are ardent advocates of almost all of them. The black or German race was the first imported, very early in the history of the country, and is found everywhere, but usually not entirely pure. As a rule this race is not desirable. No attention has been paid to breeding it for improvement in this country, and it is usually found in the hands of careless bee keepers. As a result, it is inferior, although it often produces beautiful comb honey.

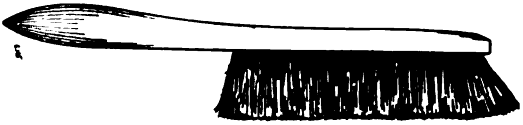
Fig. 9.—Bee brush.

The Italian bees, the next introduced, are the most popular race among the best bee keepers in this country, and with good reason. They are vigorous workers and good honey gatherers, defend their hives well, and above all have been more carefully selected by American breeders than any other race. Especially for the last reason it is usually desirable to keep this race. That almost any other race of bees known could be bred to as high a point as the Italians, and perhaps higher, can not be doubted, but the bee keeper now gets the benefit of what has been done for this race. It should not be understood from this that the efforts at breeding have been highly successful. On the contrary, bee breeding will compare very unfavorably with the improvement of other animals or plants which have been the subject of breeding investigations.

Italian bees have been carefully selected for color by some breeders to increase the area of yellow on the abdomen, until we now have what are known as "five-banded" bees. These are very beautiful, but it can scarcely be claimed that they are improved as honey producers or in regard to gentleness. They are kept mostly by amateurs.

Some breeders have claimed to select Italians for greater length of tongue, with the object of getting a bee which could obtain the abundance of nectar from red clover. If any gain is ever made in this respect it is soon lost. The terms "red-clover bees" or "long-tongued bees" are somewhat misleading, but are ordinarily used as indicating good honey producers.

Caucasian bees, recently distributed throughout the country by this Department, are the most gentle race of bees known. They are not stingless, however, as is often stated in newspapers and other periodicals. Many report them as good honey gatherers. They are more prolific than Italians and may possibly become popular. Their worst characteristic is that they gather great quantities of propolis and build burr and brace combs very freely. They are most desirable bees for the amateur or for experimental purposes.

Carniolan and Banat bees have some advocates, and are desirable in that they are gentle. Little is known of Banats in this country. Carniolans swarm excessively unless in large hives. Cyprians were formerly used somewhat, but are now rarely found pure, and are undesirable either pure or in crosses because of the fact that they sting with the least provocation and are not manageable with smoke. They are good honey gatherers, but their undesirable qualities have caused them to be discarded by American bee keepers. "Holy-land," Egyptian, and Punic (Tunisian) bees have also been tried and have been universally abandoned.

BEE BEHAVIOR.

The successful manipulation of bees depends entirely on a knowledge of their habits. This is not generally recognized, and most of the literature on practical bee keeping consists of sets of rules to guide manipulations. This is too true of the present paper, but is due to a desire to make the bulletin short and concise. While this method usually answers, it is nevertheless faulty, in that, without a knowledge of fundamental principles of behavior, the bee keeper is unable to recognize the seemingly abnormal phases of activity, and does not know what to do under such circumstances. Rules must, of course, be based on the usual behavior. By years of association, the bee keeper almost unconsciously acquires a wide knowledge of bee behavior, and consequently is better able to solve the problems which constantly arise. However, it would save an infinite number of mistakes and would add greatly to the interest of the work if more time were expended on a study of behavior; then the knowledge gained can be applied to practical manipulation.

A colony of bees consists normally of one queen bee, the mother of the colony, and thousands of sexually undeveloped females called workers, which normally lay no eggs, but gather the stores, keep the hive clean, feed the young, and do the other work of the hive. During part of the year there are also present some hundreds of males or drones (often removed or restricted in numbers by the bee keeper) whose only service is to mate with young queens. These three types are easily recognized, even by a novice. In nature the colony lives in a hollow tree or other cavity, but under manipulation thrives in the artificial hives provided. The combs which form their abode are composed of wax secreted by the workers. The hexagonal cells of the two vertical layers constituting each comb have interplaced ends on a common septum. In the cells of these combs are reared the developing bees, and here are stored honey and pollen for food.

The cells built naturally are not all of the same size, those used in rearing worker bees being about one-fifth of an inch across, and those used in rearing drones and in storing honey about one-fourth of an inch across (fig. 10). The storage cells are more irregular, and generally curve upward at the outer end. Under manipulation, the size of the cells is controlled by the bee keeper by the use of comb foundation—sheets of pure beeswax on which are impressed the bases of cells and on which the bees build the side walls.

In the North, when the activity of the spring begins, the normal colony consists of the queen and some thousands of workers. As the workers bring in early pollen and honey, the queen begins to lay eggs in the worker cells. These in time develop into white larvæ, which grow to fill the cells. They are then capped over and transform gradually into adult worker bees. As the weather grows warmer, and the colony increases in size by the emergence of the developing bees, the quantity of brood is increased. The workers continue to bring in pollen, and nectar to be made into honey. After a time the queen begins to lay eggs in the larger cells, and these develop into drones or males.

Continued increase of the colony would result in the formation of enormous colonies, and unless some division takes place no increase in the number of colonies will result. Finally, however, the workers begin to build queen cells over certain female larvæ. These are larger than any other cells in the hive and hang on the comb vertically. In size and shape they may be likened to a peanut and are also rough on the outside. When the larvæ in these cells have grown to full size they too are sealed up, and the colony is then ready for swarming.

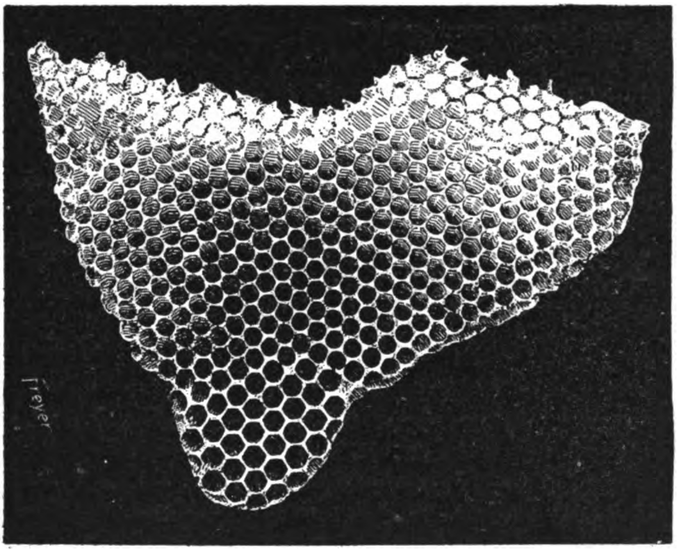

FIG. 10.—Piece of comb showing worker and drone cells with irregular transitions. Reduced.

Swarming consists of the exit from the hive of the original queen with part of the workers. They leave the hive to seek a new home and begin the building of combs, storing of honey and pollen, and rearing of brood in a new location. They leave behind the honey stores, except such as they can carry in their honey stomachs, and the brood, some workers, and no adult queen, but several queen cells from which will later emerge young queens. By this interesting process the original colony is divided into two.

The swarm finds a new location either in a hollow tree or, if cared for by the bee keeper, in a hive. The workers build new combs, the queen begins laying, and in a short time the colony is again in normal condition.

The colony on the old stand (parent colony) has the advantage of the bees which emerge from the brood. After a time (usually about nine days), the queens in their cells are ready to emerge. If the colony is only moderately strong the first queen to emerge is allowed by the workers to tear down the other queen cells and kill the queens not yet emerged, but if a "second swarm" is to be given off the queen cells are protected.

If the weather permits, after from five to eight days the young queen flies from the hive to mate with a drone. Mating usually occurs but once during the life of the queen and always takes place on the wing. In this single mating she receives enough spermatozoa to last throughout her life. She returns to the hive after mating, and in about two days begins egg laying. The queen never leaves the hive except at mating time or with a swarm, and her sole duty in the colony is to lay eggs to keep up the population.

When the flowers are in bloom which furnish most nectar, the bees usually gather more honey than they need for their own use, and this the bee keeper can safely remove. They continue the collection of honey and other activities until cold weather comes on in the fall, when brood rearing ceases; they then become relatively quiet, remaining in the hive all winter, except for short flights on warm days. When the main honey flow is over, the drones are usually driven from the hive. By that time the virgin queens have been mated and drones are of no further use. They are not usually stung to death, but are merely carried or driven from the hive by the workers and starve. A colony of bees which for any reason is without a queen does not expel the drones.

Many abnormal conditions may arise in the activity of a colony, and it is therefore necessary for the bee keeper to understand most of these, so that when they occur he may overcome them. If a virgin queen is prevented from mating she generally dies, but occasionally begins to lay eggs after about four weeks. In this event, however, all of the eggs which develop become males. Such a queen is commonly called a "drone-layer."

If the virgin queen is lost while on her flight or the colony at any other time is left queenless without means of rearing additional queens, it sometimes happens that some of the workers begin to lay eggs. These eggs also develop only into drones.

It also happens at times that when a queen becomes old her supply of spermatozoa is exhausted, at which time her eggs also develop only into drones. These facts are the basis of the theory that the drone of the bee is developed from an unfertilized egg or is parthenogenetic. A full discussion of this point is impossible at this time.

The work of the hive is very nicely apportioned among the inmates, so that there is little lost effort. As has been stated, the rearing of young is accomplished by having one individual to lay eggs and numerous others (immature females) to care for the larvæ. In like manner all work of the colony is apportioned. In general, it may be stated that all inside work—wax building, care of brood, and cleaning—is done by the younger workers, those less than 17 days old, while the outside work of collecting pollen and nectar to be made into honey is done by the older workers. This plan may be changed by special conditions. For example, if the colony has been queenless for a time and a queen is then given, old workers may begin the inside work of feeding larvæ and these may also secrete wax. Or, if the old workers are all removed, the younger bees may begin outside work. As a rule, however, the general plan of division of labor according to age is followed rather closely.

DIRECTIONS FOR GENERAL MANIPULATIONS.

Bees should be handled so that they will be little disturbed in their work. As much as possible, stings should be avoided during manipulation. This is true not so much because they are painful to the operator, but because the odor of poison which gets into the air irritates the other bees and makes them more difficult to manage. For this reason it is most advisable to wear a black veil (fig. 4) over a wide-brimmed hat and to have a good smoker (fig. 3). Experienced bee keepers often dispense with these, but the beginner should not. Gloves, however, are usually more an inconvenience than otherwise. Gauntlets or rubber bands around the cuffs keep the bees from crawling up the sleeve. It is best to avoid black clothing, since that color seems to excite bees; a black felt hat is especially to be avoided.

The bee keeper should manipulate without exhibiting fear. This is not because the bees recognize the fact that the operator is afraid of them, as some claim, but because superfluous quick movements tend to irritate the bees. The hive should not be jarred or disturbed any more than necessary. Rapid movements are objectionable, because with their peculiar eye structure bees probably perceive motion more readily than they do objects. Persons not accustomed to bees, on approaching a hive, often strike at bees which fly toward them or make some quick movement of the head or hand to avoid the sting which they fear is to follow. This is just what should not be done, for the rapid movement, even if not toward the bee, is far more likely to be followed by a sting than is remaining quiet.

The best time to handle bees is during the middle of warm days, particularly during a honey flow. Never handle bees at night or on cold, wet days unless absolutely necessary. The work of a beginner may be made much easier and more pleasant by keeping gentle bees. Caucasians, Carniolans, Banats, and some strains of Italians ordinarily do not sting much unless unusually provoked or except in bad weather. Common black bees or crosses of blacks with other races are more irritable. It may be well worth while for the beginner to procure gentle bees while gaining experience in manipulation. Later on, this is less important, for the bee keeper learns to handle bees with the least inconvenience to himself or to them.

Before opening a hive the smoker should be lighted and the veil put on. A few puffs of smoke directed into the entrance will cause the bees to fill themselves with honey and will drive back the guards. The hive cover should be raised gently, if necessary being pried loose with a screw-driver or special hive tool. As soon as a small opening is made, more smoke should be blown in on the tops of the frames, or if a mat covering for the frames is used, the cover should be entirely removed and one corner of the mat lifted to admit smoke. It is not desirable to use any more smoke than just enough to subdue the bees and keep them down on the frames. At any time during manipulation, if they become excited, more smoke may be used. Do not stand in front of the entrance, but at one side or the back.

After the frames are exposed they may be loosened by prying with the hive tool and crowded together a little so as to give room for the removal of one frame. In cool weather the propolis (bee glue) may be brittle. Care should be exercised not to loosen this with a jar. The first frame removed can be leaned against the hive, so that inside there will be more room for handling the others. During all manipulations bees must not be mashed or crowded, for that irritates the colony greatly and may make it necessary to discontinue operations. Undue crowding may also mash the queen. If bees crawl on the hands, they may be gently brushed off or thrown off.

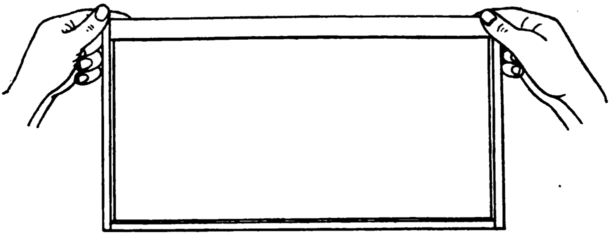

FIG. 11.—Handling the frame: First position.

In examining a frame always hold it over the hive, so that any bees or queen which fall may drop into it. Freshly gathered honey also often drops from the frame, and if it falls in the hive the bees can quickly clean it up, whereas if it drops outside it is untidy and may cause robbing. If a frame is temporarily leaned against the hive, it should be placed in a nearly upright position to prevent breakage and leaking of honey. The frame on which the queen is located should not be placed on the ground, for fear she may crawl away and be lost. It is best to lean the frame on the side of the hive away from the operator, so that bees will not crawl up the legs.

In handling frames the comb should always be held in a vertical position, especially if it contains much honey. When a frame is lifted from the hive by the top bar, one side is exposed to the operator with the comb placed vertically (fig. 11). To examine the reverse side, raise one end of the top bar until it is perpendicular (fig. 12), turn the frame on the top bar as an axis until the reverse side is in view, and then lower to a horizontal position with the top bar below (fig. 13). In this way there is no extra strain on the comb and the bees are not irritated. This care is not so necessary with wired combs, but it is a good habit to form in handling frames.

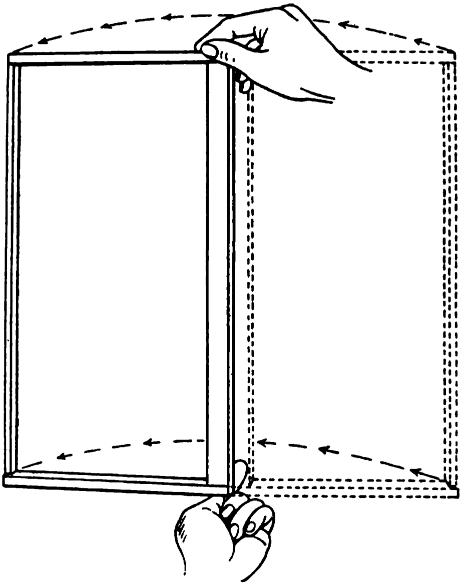

FIG. 12.—Handling the frame: Second position.

It is desirable to have combs all of worker cells to reduce the amount of drone brood. The use of full sheets of foundation will bring this about and is also of value in making the combs straight, so that bees are not mashed in removing the frame. It is extremely difficult to remove combs built crosswise in the hive, and this should never be allowed to occur. Such a hive is even worse than a plain box hive. Extra inside fixtures should be avoided, as they tend only to impede manipulation. The hive should also be placed so that the entrance is perfectly horizontal and a little lower than the back of the hive. The frames will then hang in a vertical position, and the outer ones will not be fastened to the hive body if properly spaced at the top.

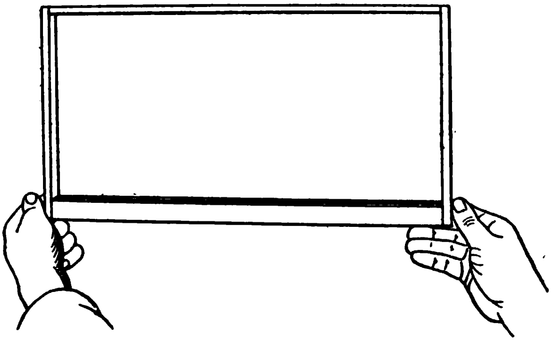

FIG. 13.—Handling the frame: Third position.

Various remedies for bee stings have been advocated, but they are all useless. The puncture made by the sting is so small that it closes when the sting is removed and liquids can not be expected to enter. The best thing to do when stung is to remove the sting as soon as possible without squeezing the poison sac, which is usually attached. This can be done by scraping it out with a knife or finger nail. After this is done the injured spot should be let alone and not rubbed with any liniment. The intense itching will soon disappear; any irritation only serves to increase the after swelling.

In placing frames in the hive great care should be exercised that they are properly spaced. Some frames are self-spacing, having projections on the side, so that when placed as close as possible they are the correct distance apart. These are good for beginners or persons who do not judge distances well and are preferred by many professional bee keepers. If unspaced frames are used, they should be 1⅜ inches from center to center. A little practice will usually enable anyone to space quickly and accurately. Careful spacing is necessary to prevent the building of combs of irregular thickness and to retard the building of pieces of comb from one frame to another.

A beginner in bee keeping should by all means, if possible, visit some experienced bee keeper to get suggestions in handling bees. More can be learned in a short visit than in a considerably longer time in reading directions, and numerous short cuts which are acquired by experience will well repay the trouble or expense of such a visit. Not all professional bee keepers manipulate in the very best way, but later personal experience will correct any erroneous information. Above all, personal experimenting and a study of bee activity are absolute necessities in the practical handling of bees.

TRANSFERRING.

In increasing the apiary it is sometimes best to buy colonies in box hives on account of their smaller cost and to transfer them to hives with movable frames. This should be done as soon as possible, for box-hive colonies are of small value as producers. The best time to transfer is in the spring (during fruit bloom in the North) when the amount of honey and the population of the colony are at a minimum.

Transferring should not be delayed until spring merely because that season is best for the work. It may be done at any time during the active season, but, whenever possible, during a honey flow, to prevent robbing. If necessary, it may be done in a tent such as is often used in manipulating colonies. By choosing a time of the day when the largest number of bees are in the field the work will be lessened.

The box hive should be moved a few feet from its stand and in its place should be put a hive containing either full sheets of foundation or empty combs. The box hive should be turned upside down and a small, empty box fitted on it. By drumming continuously on the box hive for a considerable time the bees will be made to desert their combs and go to the upper box, and when most of them are clustered above the box may be carried to the new hive and the bees dumped in front of the entrance. The queen will usually be seen as the bees enter the hive, but, in case she has not left the old combs, more drumming will induce her to leave. It is necessary that the queen be in the hive before this manipulation is finished. The old box hive containing brood may now be placed right side up in a new location and in twenty-one days all of the worker brood will have emerged and probably some new queens will have been reared. These bees may then be drummed out and united with their former hive mates by smoking the colony and the drummed bees vigorously and allowing the latter to enter the hive through a perforated zinc to keep out the young queens. The wax in the box hive may then be melted up and any honey which it may contain used as the bee keeper sees fit. By this method good straight combs are obtained. If little honey is being gathered, the colony in the hive must be provided with food.

If, on the other hand, the operator desires to save the combs of the box hive, the bees may be drummed into a box and the brood combs and other fairly good combs cut to fit frames and tied in place or held with rubber bands, strings, or strips of wood until the bees can repair the damage and fill up the breaks. These frames can then be hung in a hive on the old stand and the bees allowed to go in. The cutting of combs containing brood with more or less bees on them is a disagreeable job and, since the combs so obtained are usually of little value in an apiary, the first method is recommended.

Colonies often take up their abode in walls of houses and it is often necessary to remove them to prevent damage from melting combs. If the cavity in which the combs are built can be reached, the method of procedure is like that of transferring, except that drumming is impractical and the bees must simply be subdued with smoke and the combs cut out with the bees on them.

Another method which is often better is to place a bee escape over the entrance to the cavity, so that the bees can come out, but can not return. A cone of wire cloth about 8 inches high with a hole at the apex just large enough for one bee to pass will serve as a bee escape, or a regular bee escape such as are sold by dealers may be used. A hive which they can enter is then placed beside the entrance. The queen is not obtained in this way and, of course, goes right on laying eggs, but as the colony is rapidly reduced in size the amount of brood decreases. As brood emerges, the younger bees leave the cavity and join the bees in the hive, until finally the queen is left practically alone. A new queen should be given to the bees in the hive as soon as possible, and in a short time they are fully established in their new quarters. After about four weeks, when all or nearly all of the brood in the cavity has emerged, the bee escape should be removed and as large a hole made at the entrance of the cavity as possible. The bees will then go in and rob out the honey and carry it to the hive, leaving only empty combs. The empty combs will probably do no damage, as moths usually soon destroy them and they may be left in the cavity and the old entrance carefully closed to prevent another swarm from taking up quarters there.

In transferring bees from a hollow tree the method will depend on the accessibility of the cavity. Usually it is difficult to drum out the bees and the combs can be cut out after subduing the colony with smoke.

UNITING.

Frequently colonies become queenless when it is not practicable to give them a new queen, and the best practice under such conditions is to unite the queenless bees to a normal colony. If any colonies are weak in the fall, even if they have a queen, safe wintering is better insured if two or more weak colonies are united, keeping the best queen. Under various other conditions which may arise the bee keeper may find it desirable to unite bees from different colonies. Some fundamental facts in bee behavior must be thoroughly understood to make this a success.

Every colony of bees has a distinctive colony odor and by this means bees recognize the entering of their hive by bees from other colonies and usually resent it. If, however, a bee comes heavily laden from the field and flies directly into the wrong hive without hesitation it is rarely molested. In uniting colonies, the separate colony odors must be hidden, and this is done by smoking each colony vigorously. It may at times be desirable to use tobacco smoke, which not only covers the colony odor but stupefies the bees somewhat. Care should be taken not to use too much tobacco, as it will completely overcome the bees. The queen to be saved should be caged for a day or two to prevent the strange bees from killing her in the first excitement.

Another fact which must be considered is that the bees of a colony carefully mark the location of their own hive and remember that location for some time after they are removed. If, therefore, two colonies in the apiary which are not close together are to be united, they should be moved gradually nearer, not more than a foot at a time, until they are side by side, so that the bees will not return to their original locations and be lost. As the hives are moved gradually the slight changes are noted and no such loss occurs. As a further precaution, a board should be placed in front of the entrance in a slanting position, or brush and weeds may be thrown down so that when the bees fly out they recognize the fact that there has been a change and accustom themselves to the new place. If uniting can be done during a honey flow, there is less danger of loss of bees by fighting, or if done in cool weather, when the bees are not actively rearing brood, the colony odors are diminished and the danger is reduced.

It is an easy matter to unite two or more weak swarms to make one strong one, for during swarming the bees have lost their memory of the old location, are full of honey, and are easily placed wherever the bee keeper wishes. They may simply be thrown together in front of a hive. Swarms may also be given to a newly established colony with little difficulty.

PREVENTING ROBBING IN THE APIARY.

When there is no honey flow bees are inclined to rob other colonies, and every precaution must be taken to prevent this. Feeding often attracts other bees, and, if there are indications of robbing, the sirup or honey should be given late in the day. As soon as robbing begins, manipulation of colonies should be discontinued, the hives closed, and, if necessary, the entrances contracted as far as the weather will permit. If brush is thrown in front of the entrance, robbers are less likely to attempt entering. At all times honey which has been removed from the hives should be kept where no bees can get at it, so as not to incite robbing.

FEEDING.

During spring manipulations, in preparing bees for winter, and at other times it may be necessary to feed bees for stimulation or to provide stores. *Honey from an unknown source should never be used*, for fear of introducing disease, and sirup made of granulated sugar is cheapest and best for this purpose. The cheaper grades of sugar or molasses should never be used for winter stores. The proportion of sugar to water depends on the season and the purpose of the feeding. For stimulation a proportion of one-fourth to one-third sugar by volume is enough, and for fall feeding, especially if rather late, a solution containing as much sugar as it will hold when cold is best. There seems to be little advantage in boiling the sirup. Tartaric acid in small quantity may be added for the purpose of changing part of the cane sugar to invert sugar, thus retarding granulation. The medication of sirup as a preventive or cure of brood disease is often practiced, but it has not been shown that such a procedure is of any value. If honey is fed, it should be diluted somewhat, the amount of dilution depending on the season. If robbing is likely to occur, feeding should be done in the evening.

Numerous feeders are on the market, adapted for different purposes and methods of manipulation (figs. 14, 15, 16). A simple feeder can be made of a tin pan filled with excelsior or shavings (fig. 17). This is filled with sirup and placed on top of the frames in a super or hive body. It is advisable to lean pieces of wood on the pan as runways for the bees, and to attract them first to the sirup, either by mixing in a little honey or by spilling a little sirup over the frames and sticks.

It may be stated positively that it does not pay financially, or in any other way, to feed sugar sirup to be stored in sections and sold as comb honey. Of course, such things have been tried, but the consumption of sugar during the storing makes the cost greater than the value of pure floral honey.

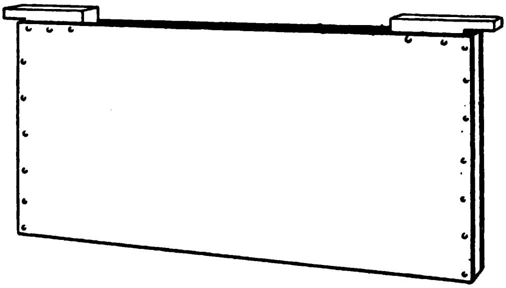

FIG. 14.—Division-board feeder to be hung in hive in place of frame.

SPRING MANAGEMENT.

The condition of a colony of bees in the early spring depends largely on care in the preceding autumn and in the method of wintering. If the colony has wintered well and has a good prolific queen, preferably young, the chances are that it will become strong in time to store a good surplus when the honey flow comes.

The bees which come through the winter, reared the previous autumn, are old and incapable of much work. As the season opens they go out to collect the early nectar and pollen, and also care for the brood which hatches from the eggs laid by the queen. The amount of brood is at first small, and as the new workers emerge they assist in the brood rearing so that the extent of the brood can be gradually increased until it reaches the maximum at the beginning of the summer. The old bees die off rapidly.

If brood rearing does not continue late in the fall, so that the colony goes into winter with a large percentage of young bees, the old bees may die off in the spring faster than they are replaced by emerging brood. This is known as "spring dwindling." A remedy for this may be applied by feeding, if necessary, the autumn before, or keeping up brood rearing by some other means as late as possible.

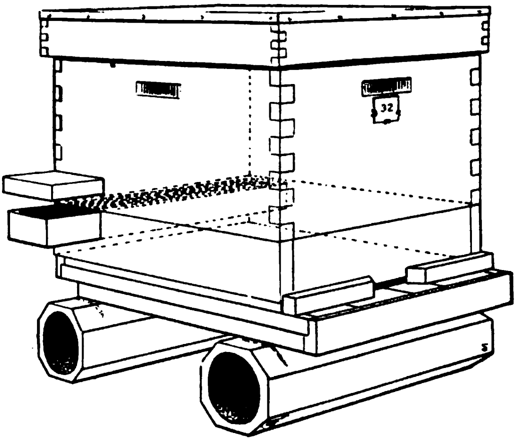

FIG. 15.—Feeder set in collar under hive body.

If spring dwindling begins, however, it can be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all the energy of the old bees may be put to the best advantage in rearing brood to replace those dying off. The size of the brood chamber can also be reduced to conserve heat.

It sometimes happens that when a hive is examined in the spring the hive body and combs are spotted with brownish yellow excrement. This is an evidence of what is commonly called "dysentery." The cause of this trouble is long-continued confinement with a poor quality of honey for food. Honey-dew honey and some of the inferior floral honeys contain a relatively large percentage of material which bees can not digest, and, if they are not able to fly for some time, the intestines become clogged with fæcal matter and a diseased condition results. Bees never normally deposit their fæces in the hive. The obvious preventive for this is to provide the colony with good honey or sugar sirup the previous fall. "Dysentery" frequently entirely destroys colonies, but if the bees can pull through until warm days permit a cleansing flight they recover promptly.

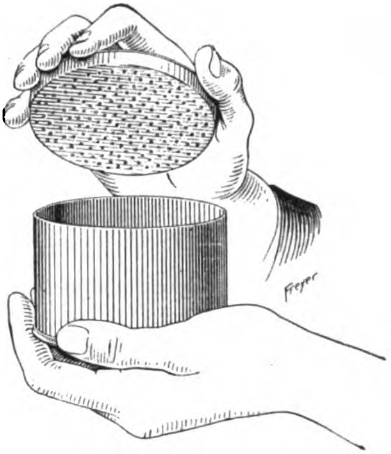

FIG. 16.—"Pepper-box" feeder for use on top of frames.

Bees should not be handled in the early spring any more than necessary, for to open a hive in cool weather wastes heat and may even kill the brood by chilling. The hive should be kept as warm as possible in early spring as an aid to brood rearing. It is a good practice to wrap hives in *black* tar paper in the spring, not only that it may aid in conserving the heat of the colony, but in holding the sun's heat rays as a help to the warmth of the hive. This wrapping should be put on as soon as an early examination has shown the colony to be in good condition, and there need be no hurry in taking it off. A black wrapping during the winter is not desirable, as it might induce brood rearing too early and waste the strength of the bees.

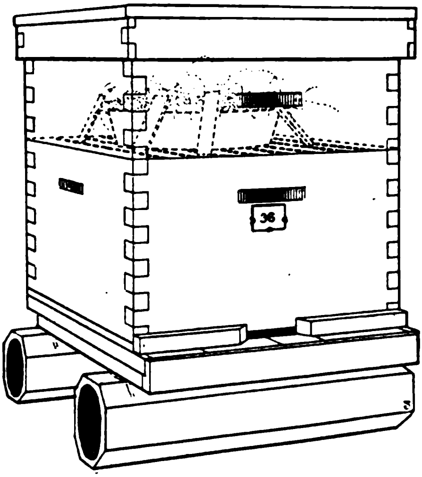

FIG. 17.—Pan in super arranged for feeding.

As a further stimulus to brood rearing, many bee keepers practice stimulative feeding of sugar sirup in early spring. This produces the same effect as a light honey flow does and the results are good. Others prefer to give the bees such a large supply of stores in the fall that when spring comes they will have an abundance for brood rearing, and it will not be necessary to disturb them in cool weather. Both ideas are good, but judicious stimulative feeding usually more than pays for the labor. Colonies should be fed late in the day, so that the bees will not fly as a result of it, and so that robbing will not be started. When the weather is warmer and more settled, the brood cluster may be artificially enlarged by spreading the frames so as to insert an empty comb in the middle. The bees will attempt to cover all the brood that they already had, and the queen will at once begin laying in the newly inserted comb, thus making a great increase in the brood. This practice is desirable when carefully done, but may lead to serious results if too much new brood is produced. A beginner had better leave the quantity of brood to the bees.

It is desirable early in the season, before any preparations are made for swarming, to go through the apiary and clip one wing of each queen so that if a swarm issues the queen can not fly and the bees can be easily returned to the old stand. This should be done before the hive becomes too populous. It is perhaps best to clip queens as they are introduced, but some colonies may rear new ones without the knowledge of the owner, and a spring examination will insure no escaping swarms.

Queens sometimes die during the winter and early spring, and since there is no brood from which the bees can replace them, the queenless colonies are "hopelessly queenless." Such colonies are usually restless and are not active in pollen gathering. If, on opening a colony, it is found to be without a queen and reduced in numbers, it should be united with another colony by smoking both vigorously and caging the queen in the queen-right colony for a day or two to prevent her being killed. A frame or two of brood may be added to a queenless colony, not only to increase its strength, but to provide young brood from which they can rear a queen. Bee keepers in the North can frequently buy queens from southern breeders early in the spring, and naturally this is better than leaving the colony without a queen until the bees can rear one, as it is important that there be no stoppage in brood rearing at this season.

SWARM MANAGEMENT AND INCREASE.

The excessive rearing of brood at the wrong season or increase in the number of colonies greatly reduces the surplus honey crop by consumption. The ideal to which all progressive bee keepers work, when operating simply for honey, is to stimulate brood rearing to prepare bees for gathering, to retard breeding when it is less desirable, and to prevent swarming. Formerly the measure of success in bee keeping was the amount of increase by swarming, but this is now recognized as being quite the contrary of success.

The stimulation of brood rearing in the spring, however, makes it more likely that swarming will occur; so that the operator must counteract that tendency. This is especially true in comb-honey production. Very few succeed in entirely preventing swarming, but by various methods the situation can be largely controlled.

When a swarm issues, it usually first settles on a limb of a tree or bush near the apiary. It was formerly common to make a noise by beating pans or ringing bells in the belief that this causes the swarm to settle. There is no foundation for such action on the part of the bee keeper. If the bees light on a small limb that can be spared, it may simply be sawed off and the bees carried to the hive and thrown on a sheet or hive cover in front of the entrance. If the limb can not be cut, the swarm can be shaken off into a box or basket on a pole and hived. If the bees light on the trunk of a tree or in some inaccessible place, they can first be attracted away by a comb, preferably containing unsealed brood. In these manipulations it is not necessary to get all the bees, but if the queen is not with those which are put in the hive the bees will go into the air again and join the cluster.

If a queen is clipped as recommended under "Spring management" (p. 24) the swarm will issue just the same, but the queen, not being able to fly, will simply wander about on the ground in front of the hive, where she can be caught and caged. The parent colony can then be removed to a new stand and a new hive put in its place. The bees will soon return and the queen can be freed among them as they enter. The field bees on returning will enter the new hive with the swarm, thus decreasing still more the parent colony and making a second swarm less probable. To make sure of this, however, all queen cells except one good one can be removed soon after the swarm issues. To hold a swarm it is desirable to put one frame containing unsealed brood in the new hive. The other frames may contain full sheets or starters of foundation or drawn combs. Usually comb-honey supers or surplus bodies for extracting frames will have been put on before swarming occurs. These are given to the swarm on the old stand and separated from the brood chamber by queen-excluding perforated zinc.

When clipping the queen's wing is not practiced, swarms may be prevented from leaving by the use of queen traps of perforated zinc (fig. 6). These allow the workers to pass out, but not drones or queens, which, on leaving the entrance, pass up to an upper compartment from which they can not return. These are also used for keeping undesirable drones from escaping, and the drones die of starvation. When a swarm issues from a hive provided with a queen trap, the queen goes to the upper compartment and remains there until released by the bee keeper. The workers soon return to the hive. When the operator discovers the queen outside, the colony may be artificially swarmed to prevent another attempt at natural swarming. A queen trap should not be kept on the hive all the time for fear the old queen may be superseded and the young queen prevented from flying out to mate.

ARTIFICIAL SWARMING.

If increase is desired, it is better to practice some method of artificial swarming and to forestall natural swarming rather than be compelled to await the whims of the colonies. The situation should be under the control of the bee keeper as much as possible. The bees, combs, and brood may be divided into two nearly equal parts and a queen provided for the queenless portion; or small colonies, called nuclei, may be made from the parent colony, so reducing its strength that swarming is not attempted. These plans are not as satisfactory as shaken swarms, since divided colonies lack the vigor of swarms.

A good method of artificially swarming a colony is to shake most of the bees from the combs into a new hive on the old stand with starters (narrow strips) of foundation. The hive containing the brood with some bees still adhering is then moved to a new location. If receptacles for surplus honey have been put on previously, as they generally should be, they should now be put over the artificial swarm separated from the brood compartment by perforated zinc.

This method of artificially swarming (usually called by bee keepers "shook" swarming) should not be practiced too early, since natural swarming may take place later. The colony should first have begun its preparations for swarming. The method is particularly useful in comb-honey production. The bees may be prevented from leaving the hive by the use of a drone trap (fig. 6) or by putting in one frame containing unsealed brood. Some bee keepers prefer using full sheets of foundation or even drawn combs for the artificial swarm, but narrow strips of foundation have some advantages. By using narrow strips the queen has no cells in which to lay eggs for a time, thus reducing brood rearing, but, since by the time artificial swarming is practiced the profitable brood rearing is over, this is no loss but rather a gain. There are also in the brood compartment no cells in which the gathering workers can deposit fresh honey, and they consequently put it above in the supers. Gradually the combs below are built out and brood rearing is increased. Later the colony is allowed to put honey in the brood combs for its winter supply. If no increase is desired, the bees which emerge from the removed brood combs may later be united with the artificial swarm and by that time there will usually be little danger of natural swarming.

PREVENTION OF SWARMING.

Unless increase is particularly desired, both natural and artificial swarming should be done away with as far as possible, so that the energy of the bees shall go into the gathering of honey. Since crowded and overheated hives are particularly conducive to swarming, this tendency may be largely overcome by giving plenty of ventilation and additional room in the hive. Shade is also a good preventive of swarming. Extra space in the hive may be furnished by adding more hive bodies and frames or by frequent extracting, so that there may be plenty of room for brood rearing and storage at all times. These manipulations are, of course, particularly applicable to extracted-honey production.

To curb the swarming impulse frequent examinations of the colonies (about every week or ten days during the swarming season) for the purpose of cutting out queen cells is a help, but this requires considerable work, and since some cells may be overlooked, and particularly since it frequently fails in spite of the greatest care, it is not usually practiced. Requeening with young queens early in the season, when possible, generally prevents swarming.

Swarming is largely due to crowded brood chambers, and since eggs laid immediately before and during the honey flow do not produce gatherers, several methods have been tried of reducing the brood. The queen may either be entirely removed or be caged in the hive to prevent her from laying. In either event the bees will usually build queen cells to replace her, and these must be kept cut out. These plans would answer the purpose very well were it not for the fact that queenless colonies often do not work vigorously. Under most circumstances these methods can not be recommended. A better method is to remove brood about swarming time and thus reduce the amount. There are generally colonies in the apiary to which frames of brood can be given to advantage.

In addition to these methods various nonswarming devices have been invented, and later a nonswarming hive so constructed that there is no opportunity for the bees to form a dense cluster. The breeding of bees by selecting colonies with less tendency to swarm has been suggested, but nothing has been accomplished along that line.

On the whole, the best methods are the giving of plenty of room, shade, and ventilation to colonies run for extracted honey; and ventilation, shade, and artificial swarming of colonies run for comb honey. Frequent requeening (about once in two years) is desirable for other reasons, and requeening before swarming time helps in the solution of that difficulty.

PREPARATION FOR THE HARVEST.

An essential in honey production is to have the hive overflowing with bees at the beginning of the honey flow, so that the field force will be large enough to gather more honey than the bees need for their own use. To accomplish this, the bee keeper must see to it that brood rearing is heavy some time before the harvest, and he must know accurately when the honey flows come, so that he may time his manipulations properly. Brood rearing during the honey flow usually produces bees which consume stores, while brood reared before the flow furnishes the surplus gatherers. The best methods of procedure may be illustrated by giving as an example the conditions in the white-clover region.

In the spring the bees gather pollen and nectar from various early flowers, and often a considerable quantity from fruit bloom and dandelions. During this time brood rearing is stimulated by the new honey, but afterwards there is usually a period of drought when brood rearing is normally diminished or not still more increased as it should be. This condition continues until the white-clover flow comes on, usually with a rush, when brood rearing is again augmented. If such a condition exists, the bee keeper should keep brood rearing at a maximum by stimulative feeding during the drought. When white clover comes in bloom he may even find it desirable to prevent brood rearing to turn the attention of his bees to gathering.

A worker bee emerges from its cell twenty-one days after the egg is laid, and it usually begins field work in from fourteen to seventeen days later. It is evident, therefore, that an egg must be laid five weeks before the honey flow to produce a gatherer. Since the flow continues for some time and since bees often go to the field earlier than fourteen days, egg laying should be pushed up to within two or three weeks of the opening of the honey flow. In addition to stimulative feeding, the care of the colony described under the heading of "Spring management" (p. 24) will increase brood production.

THE PRODUCTION OF HONEY.

The obtaining of honey from bees is generally the primary object of their culture. Bees gather nectar to make into honey for their own use as food, but generally store more than they need, and this surplus the bee keeper takes away. By managing colonies early in the spring as previously described, the surplus may be considerably increased. The secret of maximum crops is to "Keep all colonies strong."

Honey is gathered in the form of nectar secreted by various flowers, transformed by the bees, and stored in the comb. Bees also often gather a sweet liquid called "honeydew," produced by various scale insects and plant-lice, but the honeydew honey made from it is quite unlike floral honey and should not be sold for honey. It is usually unpalatable and should never be used as winter food for bees. When nectar or honeydew has been thickened by evaporation and otherwise changed, the honey is sealed in the cells with cappings of beeswax.

It is not profitable to cultivate any plant solely for the nectar which it will produce, but various plants, such as clovers, alfalfa, and buckwheat are excellent honey plants as well as valuable for other purposes; their cultivation is therefore a benefit to the bee keeper. It is often profitable to sow some plant on waste land; sweet clovers are often used in this way. The majority of honey-producing plants are wild, and the bee keeper must largely accept the locality as he finds it and manage his apiary so as to get the largest possible amount of the available nectar. Since bees often fly as far as 2 or 3 miles to obtain nectar, it is obvious that the bee keeper can rarely influence the nectar supply appreciably.

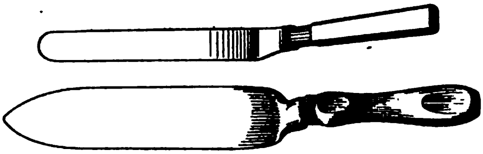

FIG. 18.—Knives for uncapping honey.

EXTRACTED HONEY.

Extracted honey is honey which has been removed by means of centrifugal force from the combs in which the bees stored it. In providing combs for the storage of honey to be extracted, the usual practice is to add to the top of the brood chamber one or more hive bodies just like the one in which brood is reared and fill these with frames. If preferred, shallower frames with bodies of proper size may be used, but most honey extractors are made for full-size frames. The surplus bodies should be put on in plenty of time to prevent the crowding of the brood chamber, and also to act as a preventive of swarming.

Honey for extracting should not be removed until it is well ripened and a large percentage of it capped. It is best, however, to remove the crop from each honey flow before another heavy producing plant comes into bloom, so that the different grades of honey may be kept separate.

The frames containing honey to be extracted are removed from the hive, the cappings cut off with a sharp, warm knife (fig. 18) made specially for this purpose, and the frames are then put into the baskets of the honey extractor (fig. 19). By revolving these rapidly the honey is thrown out of one side. The basket is then reversed and the honey from the other side is removed. The combs can then be returned to the bees to be refilled, or if the honey flow is over, they can be returned to the bees to be cleaned and then removed and stored until needed again. This method is much to be preferred to mashing the comb and straining out the honey, as was formerly done.

The extracted honey is then strained and run into vessels. It is advisable not to put it in bottles at once, but to let it settle in open vessels for a time, so that it can be skimmed. Most honeys will granulate and become quite hard if exposed to changes of temperature, and to liquefy granulated extracted honey it should be heated in a water bath. Never heat honey directly over a stove or flame, as the flavor is thereby injured. The honey should never be heated higher than 160° F. unless it is necessary to sterilize it because of contamination of disease.

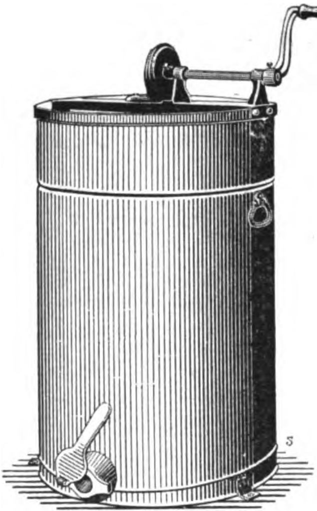
FIG. 19.—Honey extractor.

Extracted honey is put up in bottles or small tin cans for the retail trade, and in 5-gallon square tin cans or barrels for the wholesale market. Great care must be exercised if barrels are used, as honey will absorb moisture from the wood, if any is present, and cause leakage. The tin package is much to be preferred in most cases. In bottling honey for retail trade, it will well repay the bee keeper or bottler to go to considerable expense and trouble to make an attractive package, as the increased price obtained will more than make it up. Honey should be heated to 160° F. and kept there for a time before bottling, and the bottle should be filled as full as possible and sealed hermetically.[a]

COMB HONEY.

Comb honey is honey as stored in the comb by the bees, the size and shape being determined by the small wooden sections provided by the bee keeper. Instead of having comb in large frames in which to store surplus honey, the bees are compelled to build comb in the sections and to store honey there (fig. 2). A full section weighs about 1 pound; larger ones are rarely used. By the use of modern sections and foundation the comb honey now produced is a truly beautiful, very uniform product—so uniform in fact that it is often charged that it must be artificially manufactured. The purchaser of a section of comb honey may be absolutely certain, however, that he is obtaining a product of the bees, for never has anyone been able to imitate their work successfully. To show their confidence in the purity of comb honey, the National Bee Keepers' Association offers $1,000 for a single pound of artificial comb filled with an artificially prepared sirup.

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[a] For further discussion of the production and care of extracted honey, see Bulletin 75, Part I, Bureau of Entomology. It may be obtained from the Superintendent of Documents, Washington, D. C. Price 5c.

There are several different styles of sections now in use, the usual sizes being 4¼ inches square and 4 inches by 5 inches. There are also two methods of spacing, so that there will be room for the passage of bees from the brood chamber into the sections and from one super of sections to another. This is done either by cutting "bee ways" in the sides of the sections and using plain flat separators or by using "no bee-way" or plain sections and using "fences"—separators with cleats fastened on each side, to provide the bee space. To describe all the different "supers" or bodies for holding sections would be impossible in a bulletin of this size, and the reader must be referred to catalogues of dealers in bee-keeping supplies. Instead of using regular comb-honey supers, some bee keepers use wide frames to hold two tiers of sections. It is better, however, to have the supers smaller, so that the bees may be crowded more to produce full sections. To overcome this difficulty, shallow wide frames holding one tier of sections may be used. The majority of bee keepers find it advisable to use special comb-honey supers.

In producing comb honey it is even more necessary to know the plants which produce surplus honey and just when they come in bloom than it is in extracted honey production. The colony should be so manipulated that the maximum field force is ready for the beginning of the flow. This requires care in spring management, and above all the prevention of swarming. Supers should be put on just before the heavy flow begins. A good indication of the need of supers is the whitening of the brood combs at the top. If the bees are in two-hive bodies they should generally be reduced to one, and the frames should be filled with brood and honey so that as the new crop comes in the bees will carry it immediately to the sections. If large hives are used for the brood chamber it is often advisable to remove some of the frames and use a division board to crowd the bees above. To prevent the queen from going into the sections to lay, a sheet of perforated zinc (fig. 20) may be put between the brood chamber and the super (fig. 2).

It is often difficult to get bees to begin work in the small sections, but this should be brought about as soon as possible to prevent loss of honey. If there are at hand some sections which have been partly drawn the previous year, these may be put in the super with the new sections as "bait." Another good plan is to put a shallow extracting frame on either side of the sections. If a few colonies in the apiary that are strong enough to go above still refuse, lift supers from some colonies that have started to work above and give them to the slow colonies. The super should generally be shaded somewhat to keep it from getting too hot. Artificial swarming will quickly force bees into the supers.

To produce the finest quality of comb honey full sheets of foundation should be used in the sections. Some bee keepers use nearly a full sheet hung from the top of the section and a narrow bottom starter. The use of foundation of worker-cell size is much preferred.

When one super becomes half full or more and there are indications that there will be honey enough to fill others, the first one should be raised and an empty one put on the hive under it. This tiering up can be continued as long as necessary, but it is advisable to remove filled sections as soon as possible after they are nicely capped, for they soon become discolored and less attractive. Honey removed immediately after capping finds a better market, but if left on the hive even until the end of the summer the quality of the honey is improved. A careful watch must be kept on the honey flow, so as to give the bees only enough sections to store the crop. If this is not done a lot of unfinished sections will be left at the end of the flow. Honeys from different sources should never be mixed in the sections, as it gives the comb a bad appearance.

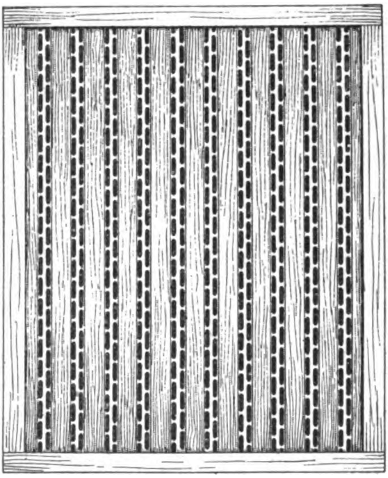

FIG. 20.—Perforated zinc queen excluder.

To remove bees from sections, the super may be put over a bee escape so that the bees can pass down but can not return, or the supers may be removed and covered with a wire-cloth-cone bee escape.

After sections are removed the wood should be scraped free of propolis (bee glue) and then packed in shipping cases (fig. 21) for the market. Shipping cases to hold 12, 24, or 48 sections, in which the various styles of sections fit exactly, are manufactured by dealers in supplies. In shipping these cases, several of them should be put in a box or crate packed in straw and paper and handles provided to reduce the chances of breakage. When loaded in a freight car the combs should be parallel with the length of the car.

In preparing comb honey for market it should be carefully graded, so that the sections in each shipping case are as uniform as possible. Nothing will more likely cause wholesale purchasers to cut the price than to find the first row of sections in a case fancy and those behind of inferior grade. Grading rules have been adopted by various bee keepers' associations or drawn up by honey dealers. The following sets of rules are in general use:

EASTERN GRADING RULES FOR COMB HONEY.

Fancy.—All sections well filled; combs straight; firmly attached to all four sides; the combs unsoiled by travel, stain, or otherwise; all the cells sealed except an occasional one; the outside surface of the wood well scraped of propolis.

A No. 1.—All sections well filled except the row of cells next to the wood; combs straight; one-eighth part of comb surface soiled, or the entire surface slightly soiled; the outside surface of the wood well scraped of propolis.

No. 1.—All sections well filled except the row of cells next to the wood; combs comparatively even; one-eighth part of comb surface soiled, or the entire surface slightly soiled.

No. 2.—Three-fourths of the total surface must be filled and sealed.

No. 3.—Must weigh at least half as much as a full-weight section.

In addition to this the honey is to be classified according to color, using the terms white, amber, and dark; that is, there will be "Fancy White," "No. 1 Dark," etc.

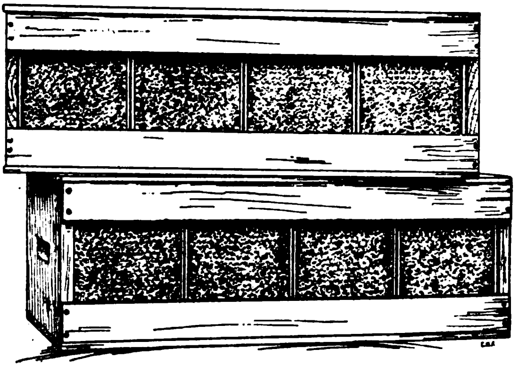

FIG. 21.—Shipping cases for comb honey.

NEW COMB-HONEY GRADING RULES ADOPTED BY THE COLORADO STATE BEE KEEPERS' ASSOCIATION.

No. 1 White.—Sections to be well filled and evenly capped, except the outside row, next to the wood; honey white or slightly amber, comb and cappings white, and not projecting beyond the wood; wood to be well cleaned; cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections

No. 1 Light Amber.—Sections to be well filled and evenly capped, except the outside row, next to the wood; honey white or light amber; comb and cappings from white to off color, but not dark; comb not projecting beyond the wood; wood to be well cleaned. Cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections.

No. 2.—This includes all white honey, and amber honey not included in the above grades; sections to be fairly well filled and capped, no more than 25 uncapped cells, exclusive of outside row, permitted in this grade; wood to be well cleaned; no section in this grade to weigh less than 12 ounces. Cases of separatored honey to average not less than 19 pounds net. Cases of half-separatored honey to average not less than 20 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 21 pounds net per case of 24 sections.

THE PRODUCTION OF WAX.

Beeswax, which is secreted by the bees and used by them for building their combs, is an important commercial product. There are times in almost every apiary when there are combs to be melted up, and it pays to take care of even scraps of comb and the cappings taken off in extracting. A common method of taking out the wax is to melt the combs in a solar wax extractor. This is perhaps the most feasible method where little wax is produced, but considerable wax still remains in old brood combs after such heating. Various wax presses are on the market, or one can be made at home. If much wax is produced, the bee keeper should make a careful study of the methods of wax extraction, as there is usually much wax wasted even after pressing.

PREPARATIONS FOR WINTERING.

After the main honey flow is over the management must depend on what may be expected later in the season from minor honey flows. If no crop is to be expected, the colony may well be kept only moderately strong, so that there will not be so many consumers in the hive.

In localities where winters are severe and breeding is suspended for several months great care should be taken that brood-rearing is rather active during the late summer, so that the colony may go into winter with plenty of young bees. In case any queens show lack of vitality they should be replaced early, so that the bees will not become queenless during the winter.

The important considerations in wintering are plenty of young bees, a good queen, plenty of stores of good quality, sound hives, and proper protection from cold and dampness.

If, as cold weather approaches, the bees do not have stores enough, they must be fed. Every colony should have from 25 to 50 pounds, depending on the length of winter and the methods of wintering. It is better to have too much honey than not enough, for what is left is good next season. If feeding is practiced, honey may be used, but sirup made of granulated sugar is just as good and is perfectly safe. If honey is purchased for feeding, great care should be taken that it comes from a healthy apiary, otherwise the apiary may be ruined by disease. *Never feed honey bought on the open market.* The bees should be provided with stores early enough so that it will not be necessary to feed or to open the colonies after cold weather comes on. Honeydew honey should not be left in the hives, as it produces "dysentery." Some honeys are also not ideal for winter stores. Those which show a high percentage of gums (most tree honeys) are not so desirable, but will usually cause no trouble.

In wintering out of doors the amount of protection depends on the severity of the winter. In the South no packing is necessary, and even in very cold climates good colonies with plenty of stores can often pass the winter with little protection, but packing and protection make it necessary for the bees to generate less heat, and consequently they consume less stores and their vitality is not reduced. Dampness is probably harder for bees to withstand than cold, and when it is considered that bees give off considerable moisture, precautions should be taken that as it condenses it does not get on the cluster. An opening at the top would allow the moisture to pass out, but it would also waste heat, so it is better to put a mat of burlap or other absorbent material on top of the frames. The hive may also be packed in chaff, leaves, or other similar dry material to keep out the cold. Some hives are made with double walls, the space being filled with chaff; these are good for outdoor wintering. The hive entrance should be lower than any other part of the hive, so that any condensed moisture may run out. The hives should be sound and the covers tight and waterproof.

Entrances should be contracted in cold weather not only to keep out cold wind, but to prevent mice from entering. There should always be enough room, however, for bees to pass in and out if warmer weather permits a flight.

In the hands of experienced bee keepers cellar wintering is very successful, but this method requires careful study. The cellar must be dry and so protected that the temperature never varies more than from 40 to 45° F.; 43° F. seems to be the optimum temperature. The ventilation must be good or the bees become fretful. Light should not be admitted to the cellar, and consequently some means of indirect ventilation is necessary.

Cellar wintering requires the consumption of less honey to maintain the proper temperature in the cluster and is therefore economical. Bees so wintered do not have an opportunity for a cleansing flight, often for several months, but the low consumption makes this less necessary. Some bee keepers advocate carrying the colonies out a few times on warm days, but it is not fully established whether this is entirely beneficial and is usually not practiced.

The time for putting colonies in the cellar is a point of dispute, and practice in this regard varies considerably. They should certainly be put in before the weather becomes severe and as soon as they have ceased brood rearing. The time chosen may be at night when they are all in the hive, or on some chilly day.

The hives may be piled one on top of the other, the lower tier raised a little from the floor. The entrances should not be contracted unless the colony is comparatively weak. It is usually not considered good policy to close the entrances with wire cloth, as the dead bees which accumulate more or less on the bottom board may cut off ventilation, and the entrance should be free so that these may be cleaned out.

The time of removing bees from the cellar is less easily determined than that of putting them in. The colonies may be removed early and wrapped in *black* tar paper or left until the weather is settled. If the weather is very warm and the bees become fretful, the cellar must either be cooled or the bees removed. Some bee keepers prefer to remove bees at night, so that they can recover from the excitement and fly from the hive normally in the morning. One of the chief difficulties is to prevent the bees from getting into the wrong hives after their first flights. They often "drift" badly with the wind, and sometimes an outside row will become abnormally strong, leaving other colonies weak.

DISEASES AND ENEMIES.

There are two infectious diseases of the brood of bees which cause great losses to the bee-keeping industry of the United States. These are known as American foul brood and European foul brood. Both of these diseases destroy colonies by killing the brood, so that there are not enough young bees emerging to take the place of the old adult bees as these die from natural causes. The adult bees are not attacked by either disease. In the hands of careful bee keepers both diseases may be controlled, and this requires careful study and constant watching. In view of the fact that these diseases are now widely distributed throughout the United States, every bee keeper should read the available literature on the subject, so that if disease enters his apiary he may be able to recognize it before it gets a start. The symptoms and the treatment recommended by this Department are given in another publication which will be sent free on request.[a]

It is difficult for a bee keeper to keep his apiary free from disease if others about him have diseased colonies which are not properly treated. The only way to keep disease under control is for the bee keepers in the neighborhood to cooperate in doing everything possible to stamp out disease as soon as it appears in a single colony. The progressive bee keeper who learns of disease in his neighborhood should see to it that the other bee keepers around him are supplied with literature describing symptoms and treatment, and should also try to induce them to unite in eradicating the malady. Since it is so often impossible to get all of the bee keepers in a community to treat infected colonies properly and promptly, it is desirable that the States pass laws providing for the inspection of apiaries and granting to the inspector the power to compel negligent bee keepers to treat diseased colonies so that the property of others may not be endangered and destroyed. This has been done in a number of States, but there are still some where the need is great and in which no such provision has been made. When no inspection is provided, bee keepers should unite in asking for such protection, so that the danger to the industry may be lessened.

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[a] Circular 79, Bureau of Entomology, U. S. Dept. of Agriculture. The Brood Diseases of Bees.

In case there is an inspector for the State or county, he should be notified as soon as disease is suspected in the neighborhood. Some bee keepers hesitate to report disease through fear that the inspector will destroy their bees or because they feel that it is a disgrace to have disease in the apiary. There is no disgrace in having colonies become diseased; the discredit is in not treating them promptly. The inspectors are usually, if not universally, good practical bee keepers who from a wide experience are able to tell what should be done in individual cases to give the best results with the least cost in material and labor. They do not destroy colonies needlessly, and, in fact, they all advocate and teach treatment.

The brood diseases are frequently introduced into a locality by the shipping in of diseased colonies; or, more often, the bees get honey from infected colonies which is fed to them, or which they rob, from discarded honey cans. It is decidedly dangerous to purchase honey on the market, with no knowledge of its source, to be used in feeding bees. Many outbreaks of disease can be traced to this practice (see "Feeding," p. 23). It is difficult to prevent bees from getting contaminated honey accidentally. If colonies are purchased, great care should be taken that there is no disease present. Whenever possible, colonies should be purchased near at home, unless disease is already present in the neighborhood.

There are other diseased conditions of the brood, known to bee keepers as pickled brood, but these can usually be distinguished from the two diseases previously mentioned. The so-called "pickled brood" is not contagious and no treatment is necessary. Bees also suffer from "dysentery," which is discussed in the earlier part of this bulletin, and from the so-called "paralysis," a disease of adult bees. No treatment for the latter disease can as yet be recommended as reliable. The sprinkling of powdered sulphur on the top bars of frames or at the entrance is sometimes claimed to be effective, but under what circumstances it is beneficial is unknown.

A number of insects, birds, and mammals must be classed as enemies of bees, but of these the two wax moths, and ants, are the only ones of importance. There are two species of moth, the larger wax moth (*Galleria mellonella* L.,) and the lesser wax moth (*Achroia grisella* Fab.), the larvæ of which destroy combs by burrowing through them.[a] Reports are frequently received in the Department that the larvæ of these moths (usually the larger species) are destroying colonies of bees. It may be stated positively that moths do not destroy strong healthy colonies in good hives, and if it is supposed that they are causing damage the bee keeper should carefully study his colonies to see what other trouble has weakened them enough for the moths to enter. Queenlessness, lack of stores, or some such trouble may be the condition favorable to the entrance of the pest, but a careful examination should be made of the brood to see whether there is any evidence of disease. This is the most frequent cause of the cases of moth depredation reported to this Department. Black bees are less capable of driving moth larvæ out, but, even with these bees, strong colonies rarely allow them to remain. The observance of the golden rule of bee keeping, "Keep all colonies strong," will solve the moth question unless disease appears.

Moth larvæ often destroy combs stored outside the hive. To prevent this the combs may be fumigated with sulphur fumes or bisulphid of carbon in tiers of hives or in tight rooms. If bisulphid of carbon is used, great care should be taken not to bring it near a flame, as it is highly inflammable. Combs should be stored in a dry, well-ventilated, light room.

In the warmer parts of the country ants are often a serious pest. They may enter the hive for protection against changes of temperature, or to prey on the honey stores or the brood. The usual method of keeping them out is to put the hive on a stand, the legs of which rest in vessels containing water or creosote. Another method is to wrap a tape soaked in corrosive sublimate around the bottom board.

GENERAL INFORMATION.

For the purpose of answering numerous questions which are asked of this Department the following brief topics are included.

BREEDERS OF QUEENS.

There are a large number of bee keepers who make a business of rearing queens of good stock for sale. The queens are usually sent by mail. If poor stock is all that can be obtained locally, it is recommended that such colonies be purchased and the queens removed and replaced with those obtained from a good breeder. This Department can supply names of breeders, nearest the applicant, of any race raised in this country.

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[a] Bee keepers refer to these insects as "moths," "wax moths," "bee moths," "millers," "wax worms," "honey moths," "moth worms," "moth millers," and "grubs." The last six terms are not correct.

INTRODUCING QUEENS.

When queens are shipped by mail they usually come in cages which can be used for introducing. If the colony to receive the new queen has one, she must be removed and the cage inserted between the frames. The small hole leading into the candy compartment is uncovered, and the bees gradually eat through and release the queen. If queens are reared at home, a similar cage may be used for introducing.

In view of the fact that disease may be transmitted in mailing cages, it is always a wise precaution to remove the new queen and destroy the accompanying workers and the cage and its contents. The queen may then be put into a clean cage without worker bees with candy known to be free from contamination (made from honey from healthy hives) and introduced in the regular way. Queens sold by breeders are always mated unless otherwise specified, and consequently the colony in which they are introduced has no effect on the offspring. During the active season the bees in the colony are all the offspring of the new queen in about nine weeks. Three weeks is required for the previous brood to emerge (if the colony has not been queenless), and in six weeks after all the old brood emerges most of the workers from it will have died.

DEALERS IN BEE KEEPERS' SUPPLIES.

There are several manufacturers of supplies in this country who can furnish almost anything desired by the bee keeper. Some of them have agents in various parts of the country from whom supplies may be purchased, thus saving considerable in freight.

BEE KEEPERS' ASSOCIATIONS.

There are a large number of associations of bee keepers in all parts of the country, formed for the betterment of the industry and a few associations which are organized to aid the members in purchasing supplies and in selling the crops. Of these the National Beekeepers' Association is the largest. It helps its members in obtaining their legal rights, and aids in securing legislation for the furtherance of the industry. The annual conventions are held in different parts of the country, and copies of the proceedings are sent to the members. There are also numerous state, county, and town associations, some of which publish proceedings. The names of officers of the nearest associations or of the National Beekeepers' Association will be sent on request from this Department.

LAWS AFFECTING BEE KEEPING.

Disease inspection.—Various States have passed laws providing for the state or county inspection of apiaries for bee-disease control, and every bee keeper should get in touch with an inspector when disease is suspected, if one is provided. The inspectors are practical bee keepers who fully understand how to control the diseases, and are of great help in giving directions in this matter. The name of the inspector of any locality can usually be furnished, and this department is glad to aid bee keepers in reaching the proper officers.

Laws against spraying fruit trees while in bloom.—The spraying of fruit trees while in bloom is not now advised by economic entomologists, and to prevent the practice some States have passed laws making it a misdemeanor. Such spraying not only kills off honeybees, causing a loss to the bee keeper, but interferes with the proper pollination of the blossoms and is thus a detriment to the fruit grower. Bee keepers should do everything in their power to prevent the practice.

Laws against the adulteration of honey.—The National Food and Drugs Act of 1906, and various state pure food laws, are a great aid to the bee keeper in preventing the sale of adulterated extracted honey as pure honey. Bee keepers can often aid in this work by reporting to the proper officials infringements of these laws which come to their notice.

When bees are a nuisance.—Some cities have passed ordinances prohibiting the keeping of bees in certain areas, but so far none have been able to enforce them. If bees are a nuisance in individual cases, the owner may be compelled to remove them. The National Beekeepers' Association will help any of its members in such cases, if they are in the right, as well as in cases where bees sting horses. Bee keepers should be careful not to locate bees where they can cause any trouble of this kind.

SUPPOSED INJURY OF CROPS BY BEES.

Bee keepers are often compelled to combat the idea that bees cause damage to fruit or other crops by sucking the nectar from the flower. This is not only untrue, but in many cases the bees are a great benefit in pollinating the flowers, making a good crop possible. A more frequent complaint is that bees puncture fruit and suck the juices. Bees never puncture sound fruit, but if the skin is broken by some other means bees will often suck the fruit dry. In doing it, however, they are sucking fruit which is already damaged. These and similar charges against the honeybee are prompted by a lack of information concerning their activities. Bees may, of course, become a nuisance to others through their stinging propensities, but bee keepers should not be criticised for things which their bees do not do.

JOURNALS AND BOOKS ON BEE KEEPING.

The progressive bee keeper will find it to his profit to subscribe for at least one journal devoted to bee keeping. Several of these are published in the United States. The names and addresses of such journals may usually be obtained from a subscription agent for periodicals, or from a supply dealer.

It will also be advantageous to read and study books on bee keeping, of which several are published in this country. These are advertised in journals devoted to bee keeping, or may usually be obtained through the local book dealer or through dealers in bee keepers' supplies.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE ON BEE KEEPING.[a]

There are several publications of this Department which are of interest to bee keepers, and new ones are added as fast as the different lines of investigation are completed.

The following publications relating to bee culture, prepared in the Bureau of Entomology, are for free distribution and may be obtained by addressing the Secretary of Agriculture:

Farmers' Bulletin No. 59, "Bee Keeping." By Frank Benton. 1905. 48 pp., 19 figs. Superseded by Farmers' Bulletin No. 397.

Farmers' Bulletin No. 397, "Bees." By E. F. Phillips, Ph. D. 1910. 44 pp., 21 figs. A general account of the management of bees.

Circular No. 79, "The Brood Diseases of Bees." By E. F. Phillips, Ph. D. 1906. 5 pp.

This publication gives briefly the symptoms of the various brood diseases, with directions for treatment.

Circular No. 94, "The Cause of American Foul Brood." By G. F. White, Ph. D. 1907. 4 pp.

This publication contains a brief account of the investigations which demonstrated for the first time the cause of one of the brood diseases of bees, American foul brood.

The following publications are not for free distribution, but may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the prices indicated. All remittances should be made payable to him and not to the Department of Agriculture, and should be sent by postal money order or by New York exchange. If currency is sent it is at the sender's risk; such remittances, however, usually arrive safely. Stamps, personal checks, or foreign money will not be accepted in any case.

BUREAU OF ENTOMOLOGY.

Bulletin No. 1, "The Honey Bee." By Frank Benton. 1899. 118 pp., 76 figs., 12 plates.

[This bulletin has been discontinued owing to the fact that later investigations have shown the error of certain portions which, when the bulletin was prepared, were generally accepted as correct. The subjects treated are discussed in the various later publications of the Bureau.]

Bulletin No. 55, "The Rearing of Queen Bees." By E. F. Phillips, Ph. D. 1905. 32 pp., 17 figs. Price 5c.

A general account of the methods used in queen rearing. Several methods are given, so that the bee keeper may choose those best suited to his individual needs.

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[a] List revised to April 1, 1910. (VI.)

Bulletin No. 70, "Report of the Meeting of Inspectors of Apiaries, San Antonio, Tex., November 12, 1906." 1907. 79 pp., 1 plate. Price 15c.

Contains an account of the history of bee-disease investigations, the relationship of bacteria to bee diseases, and a discussion of treatment by various inspectors of apiaries and other practical bee keepers who are familiar with diseases of bees.

Bulletin No. 75, Part I, "Production and Care of Extracted Honey." By E. F. Phillips, Ph. D. "Methods of Honey Testing for Bee Keepers." By C. A. Browne, Ph. D. 1907. 18 pp. Price 5c.

The methods of producing extracted honey, with special reference to the care of honey after it is taken from the bees, so that its value may not be decreased by improper handling. The second portion of the publication gives some simple tests for adulteration.

Bulletin No. 75, Part II, "Wax Moths and American Foul Brood." By E. F. Phillips, Ph. D. 1907. Pp. 19–22, 3 plates. Price 5c.

An account of the behavior of the two species of wax moths on combs containing American foul brood, showing that moths do not clean up the disease-carrying scales.

Bulletin No. 75, Part III, "Bee Diseases in Massachusetts." By Burton N. Gates. 1908. Pp. 23–32, map. Price 5c.

An account of the distribution of the brood diseases of bees in the State, with brief directions for controlling them.

Bulletin No. 75, Part IV, "The Relation of the Etiology (Cause) of Bee Diseases to the Treatment." By G. F. White, Ph. D. 1908. Pp. 33–42. Price 5c.

The necessity for a knowledge of the cause of bee diseases before rational treatment is possible is pointed out. The present state of our knowledge of the causes of disease is summarized.

Bulletin No. 75, Part V, "A Brief Survey of Hawaiian Bee Keeping." By E. F. Phillips, Ph. D. 1909. Pp. 43–58, 6 plates. Price 15c.

An account of the bee-keeping methods used in a tropical country and a comparison with mainland conditions. Some new manipulations are recommended.

Bulletin No. 75, Part VI, "The Status of Apiculture in the United States." By E. F. Phillips, Ph. D. 1909. Pp. 59–80. Price 5c.

A survey of present-day bee keeping in the United States, with suggestions as to the work yet to be done before apiculture will have reached its fullest development.

Bulletin No. 75, Part VII, "Bee Keeping in Massachusetts." By Burton N. Gates. 1909. Pp. 81–109, 2 figs. Price 5c.

An account of a detailed study of the apicultural conditions in Massachusetts. The object of this paper is to find out what are the actual conditions and needs of bee keeping in New England.

Bulletin No. 75, 7 parts. A table of contents and index to the entire bulletin will be issued soon, after which the seven parts with contents and index will be published under one cover.

Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." By G. F. White, Ph. D. 1906. 50 pp. Price 10c.

A technical study of the bacteria found under normal conditions, with special attention to those found in diseased brood.

Technical Series, No. 18, "The Anatomy of the Honey Bee." By R. E. Snodgrass. 1910. 162 pp., 57 figs. Price 20c.

An account of the structure of the bee, with technical terms omitted as far as possible. Practically all of the illustrations are new, and the various parts are interpreted according to the best usage in comparative anatomy of insects. A brief discussion of the physiology of the various organs is included.

BUREAU OF CHEMISTRY.

Bulletin No. 110, "Chemical Analysis and Composition of American Honeys." By C. A. Browne. Including "A Microscopical Study of Honey Pollen." By W. J. Young. 1908. 93 pp, 1 fig., 6 plates. Price 30c.

A very comprehensive study of the chemical composition of American honeys. This publication is technical in nature and will perhaps be little used by practical bee keepers, but it is an important contribution to apicultural literature. By means of this work the detection of honey adulteration is much aided.

Applications for the following publication may be addressed to the Secretary of Agriculture:

HAWAII AGRICULTURAL EXPERIMENTAL STATION, HONOLULU, HAWAII.

Bulletin No. 17, "Hawaiian Honeys." By D. L. Van Dine and Alice R. Thompson 1908. 21 pp., 1 plate.

A study of the source and composition of the honeys of Hawaii. The peculiar conditions found on these islands are dealt with.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 398.

FARM PRACTICE IN THE USE OF COMMERCIAL FERTILIZERS IN THE SOUTH ATLANTIC STATES.

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BY

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Scientific Assistant, Office of Farm Management,
Bureau of Plant Industry.

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1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 4, 1910.

Sir: I have the honor to transmit herewith a manuscript entitled "Farm Practice in the Use of Commercial Fertilizers in the South Atlantic States," prepared by Mr. J. C. Beavers, of the Office of Farm Management of this Bureau, and to recommend its publication as a Farmers' Bulletin.

This manuscript deals particularly with the fertilizer practice of farmers on the more important soils of the South Atlantic States in the growing of staple farm crops. It is hoped to publish later bulletins dealing with the fertilizer practices which have been found effective in other sections of the country.

Respectfully,
G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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FIG. 1. Diagram showing the quantity of phosphoric acid, ammonia, and potash used to the acre by farmers of Class A on various kinds of soil for cotton, corn, and oats 13

2. Diagram showing the quantity of phosphoric acid, ammonia, and potash used to the acre by farmers of Class B on various kinds of soil for cotton, corn, and oats 13

B. P. I.—553.

FARM PRACTICE IN THE USE OF COMMERCIAL FERTILIZERS IN THE SOUTH ATLANTIC STATES.

INTRODUCTION.

The rapid increase in the use of commercial fertilizers during the past few years has created a growing demand for more information concerning them. Many experiments have been conducted which show the effect produced by using the fertilizer constituents singly, in twos, and in threes, but much more information is needed by the average farmer concerning the quantity and the proportion in which the fertilizer constituents should be used under a given condition of farm practice on a certain soil. This knowledge is essential to the farmer to prevent his wasting money in purchasing more of any one kind of fertilizer than is necessary to produce the most profitable crops.

To make heavy applications of fertilizer is costly. The increase in the yield of crops from the use of heavy applications of fertilizer on soils deficient in humus does not always correspond to the increase in the quantity of fertilizer applied. By increasing the humus content of the soil the yield of crops will be nearer in direct proportion to the quantity of fertilizer applied. Because of the frequent failure to observe this fact there is often a great deal of waste in the present methods of using fertilizers. To prevent this waste the farmer needs to know more about the fertilizer constituents in fertilizers and the factors which influence their use.

In order to obtain practical information upon this important problem an investigation of farm practice in the use of fertilizers was begun. In this work the endeavor was made to visit the best general farms located on the various soils in the most representative farming sections of each State. The farmers, as a rule, were interviewed on their own farms, so that a study could be made of the influence which the rotation of crops and the methods of farm management had on the use of fertilizers.

The most successful and economical use of commercial fertilizers is influenced by a number of factors. Before giving the detailed results of these investigations some of the more important of these factors may be profitably discussed.

NOTE.—A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to any Member of Congress or the Secretary of Agriculture.

FACTORS WHICH INFLUENCE THE ECONOMICAL USE OF COMMERCIAL FERTILIZERS.

Some of the principal factors which influence the use of fertilizers are (1) the rotation of crops, (2) the growing of legumes, (3) the use of green manure and winter cover crops, (4) the use of barnyard manure, (5) the methods followed in preparing and cultivating the soil, and (6) the character of the soil.

THE ROTATION OF CROPS.

The kind and quantity of fertilizer required to produce the most economical yields are greatly influenced by the rotation of crops. Tobacco, for example, takes from the soil approximately ten times as much potash as phosphoric acid, while wheat requires very nearly as much phosphoric acid as potash. The cereals, grasses, and corn are all heavy consumers of nitrogen, while the legumes may gather most of their supply of nitrogen from the air. Turning under the leaves, roots, and stems of legumes also adds a supply of humus to the soil, which is essential for the maximum effect of fertilizers. By growing crops in rotation which have different fertilizer requirements the heavy drain on the soil for any one kind of fertilizer is avoided. If legumes are grown in the rotation, as cowpeas after corn or crimson clover after cotton, then the quantity of nitrogen which need be applied in fertilizers to the corn and cotton can be greatly lessened, and in some cases dispensed with entirely, while the increased humus content of the soil, due to the plowing under of the legumes, makes more efficient the fertilizers that are applied.

A rotation, therefore, which is planned to minimize the need of commercial fertilizer should include crops of different fertilizer requirements alternating with those which add humus and nitrogen to the soil. Rotations which do not include crops that improve the humus content or add nitrogen to the soil need not be expected to reduce the fertilizer bill.

THE GROWING OF LEGUMES.

The growing of legumes is one of the most important factors which influence the use of fertilizers. The legumes—cowpeas, clovers, vetches, and the like—if well supplied with root nodules gather much of the nitrogen needed for their growth from the air, and when the roots, fallen leaves, and stems of these plants decay they leave considerable nitrogen in the soil to be used by succeeding crops.[a] The need for commercial nitrogen will therefore be reduced when legumes are grown in the rotation, and this fact should always be considered when mixing the fertilizer for the succeeding crop. If legumes were grown in the rotation as often as they might be, in most sections of the South all, or nearly all, the nitrogen needed for other crops could be procured in this way.

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[a] See Farmers' Bulletin 278, U. S. Department of Agriculture, entitled "Leguminous Crops for Green Manuring," 1907.

In many sections of North Carolina and southern Virginia farmers have greatly increased the yield of their crops by growing crimson clover and other winter legumes. In every section of the southeast the great benefit derived from growing cowpeas is apparent. If enough leguminous crops were grown in this territory to furnish all the nitrogen now employed in the fertilizers used they would reduce the fertilizer bills more than $8,000,000 a year, while the yield of other crops would at the same time be increased by at least one-fourth.

THE USE OF GREEN MANURE AND WINTER COVER CROPS.

Winter cover crops reduce the need for commerical fertilizer by appropriating to their own use the soluble plant constituents left by the preceding crop that would be leached out of the soil during the rainy season in winter. When these crops are turned under in the spring they not only return to the soil the fertilizer constituents which they have gathered, but their tops and roots when decomposed furnish decayed vegetable matter, or humus, which increases bacterial action. This is believed to be an important factor in crop production.

When legumes are used as winter cover crops they serve a double purpose: (1) They prevent leaching and washing and (2) they gather nitrogen which may be used by succeeding crops. On one of the North Carolina state farms one field has been cropped in corn and crimson clover six years in succession. The clover makes its growth during the winter and early spring and is turned under about the last of April and the land prepared for corn. The fertilizer used on this field has been phosphoric acid and potash without nitrogen. Under this system of double cropping, the yield of corn has increased from 20 to more than 70 bushels an acre. This is a splendid illustration of the great benefit derived from turning under winter cover crops which add nitrogen-bearing humus to the soil.

Crops other than legumes may be used as winter covers and green manures. Any of the winter cereals may be used for this purpose, but rye is probably the best one to use, as it seldom winterkills. It also makes a rapid growth in the early spring, thus enabling the farmer to turn under considerable material in time to plant either cotton, corn, or tobacco. One of the special advantages of this crop is its ability to make a fair growth in very poor soil. For this reason it is often grown on such soil and turned under for the purpose of getting the land in a condition suitable for growing legumes. Rye is also used to good advantage as a green-manure crop in well-planned rotations on good soils. It makes an early spring growth, and when turned under green it decays rapidly. Rye is generally considered one of the best green manures for tobacco in the South Atlantic States.

THE USE OF BARNYARD MANURE.

On farms where enough cattle are kept to consume a large portion of the farm crops and the manure is carefully saved, about three-fourths of the fertilizer constituents contained in the feed consumed may be returned to the soil. This manure adds a certain amount of fertilizer constituents and thus reduces the need for artificial supplies. Manure also adds a large quantity of organic matter to the soil, which upon decaying greatly improves the physical condition of the soil and makes more readily available for crop use the mineral fertilizer constituents already in the soil. Consequently, smaller applications of commercial fertilizers will often produce better results than larger applications on soils lacking in humus.

METHODS OF PREPARING AND CULTIVATING THE SOIL.

Thorough preparation and tillage of the soil are so generally known to be important factors in the production of crops that only brief mention of them will be made. It has been demonstrated by farm practice that where the soil is plowed deep more fertilizer can be used profitably than on soil plowed shallow. Deep preparation and thorough tillage not only increase the productiveness of the soil by improving its texture, but also improve the conditions which favor the action of fertilizers. On permeable, mellow soils in good tilth fertilizers are much more efficient than on cloddy, poorly prepared, and poorly tilled ground.

THE CHARACTER OF THE SOIL.

Investigations of farm practice in the use of fertilizer have shown that there is a decided variation in the quantity and proportion in which the fertilizer constituents are required to produce like yields of the same crop on different soils. Some of the variations are discussed in detail in the following pages, with particular reference to the South Atlantic States.

Sandy soils.

Under sandy soils are included those soils of the Coastal Plain region and of the adjacent sand hills that are sand to a depth of 2 feet or more and underlaid by a very sandy subsoil. These soils vary from a rather coarse to a fine sand and occupy a considerable area of the Coastal Plain from Norfolk, Va., to Mobile, Ala.

The open structure of these soils permits the escape of soluble fertilizer constituents, especially nitrogen, and admits heat and air freely, so that organic matter decays rapidly. These combined conditions make permanent improvement of such soils difficult. To keep them in a high state of productivity a rotation of crops must be practiced that will continue to add to the soil an abundance of organic matter that will aid in holding soluble fertilizer constituents and retain soil moisture during dry weather.

Sandy loam soils.

Sandy loam soils vary from medium to fine sandy loams, and at a depth of 6 to 12 inches are underlaid by a light clay subsoil that varies in color from light red to yellow. The sandy loam soils occupy the larger part of the Coastal Plain region not covered by the sandy soils and a considerable portion of the low hills of the adjacent Piedmont section from the southern part of Virginia to the central part of Alabama.

The surface soils of this class have a finer texture than the sandy soils, and the subsoil contains clay, both of which aid in preventing the organic matter from disappearing so rapidly. The sandy loam soils are easily cultivated and are adapted to the growth of a greater variety of crops than any other soils in these States. Consequently, it is possible to arrange a crop rotation that will, with the aid of fertilizer properly used, maintain and even increase the fertility of the soil and permit the farmer to greatly increase his income.

Gray loam soils.

The term "gray loam soils" is very indefinite, but is here used to designate those soils of the Piedmont section that have a gravelly to sandy loam surface and are underlaid by a clay subsoil that varies from a yellow to a retentive red clay. The surface soil varies in depth from 4 to 10 inches, and in color from almost white to light red, with gray predominating. Soils of this class are found largely on the eastern edge of the Piedmont belt that extends across all the Southeastern States except Florida. The surface soils of this class are fairly open, but, on account of the clay subsoil, improvement of a permanent nature is less difficult than in the case of those of the Coastal Plain region. While the organic matter in these soils decays almost as rapidly as on the sandy loams, soluble fertilizer constituents are held better, and as a rule less fertilizer is required to produce like results.

Red clay soils.

Red clay soils vary in color from a light-red (which often has considerable sand and gravel intermixed) to a dark-chocolate loam having fine sand intermixed with clay and silt. The surface soil usually varies in depth according to the depth of plowing. Subsoils of this class are generally red to dark-red clay, very plastic when wet, but on drying crumble easily. Speaking in a general way, these soils occupy the upper half of the Piedmont plateau, extending through North Carolina, South Carolina, Georgia, and to about the central part of Alabama.

The retentive character of both the surface soil and subsoil of the red clay types makes them hold fertilizer constituents well. On account of the suitability of these soils for the growing of grain, grasses, and legumes it is possible to arrange a rotation of crops that will produce very profitable returns and at the same time minimize the need for commercial fertilizer. While these soils are hard to cultivate they are generally quite fertile, and may be permanently improved to a high state of productivity.

SUMMARY OF FACTORS IN FERTILIZING.

The importance of taking into consideration all the factors which influence the use of fertilizer can hardly be overestimated. A plant must have each one of the essential fertilizer constituents present in an available form or its growth will be hindered in proportion to the deficiency of the lacking constituent. When the soil is rich in a given fertilizer constituent which is present in an available form, it will not be detrimental to the crop if that constituent is omitted in the fertilizer applied. If, on the other hand, the soil be deficient in a fertilizer constituent that is omitted in the fertilizer, the crop yield will decrease in proportion to the insufficient supply of that constituent. When mixing fertilizer for the different crops, the amount of fertilizer which has been added to the soil in barnyard manure, green manures, and leguminous crops should be considered, and no more of any one fertilizer constituent should be applied than is likely to be beneficial. A crop is not benefited by supplying it with more fertilizer than is needed. An excess of one or more fertilizer constituents not only fails to increase but often decreases the yield of crops, as shown both by experiments and by field practice.

To properly adjust the fertilizer constituents the farmer must study his conditions. No definite quantity or proportion of fertilizer constituents can ever be given that will meet the needs of a crop under all conditions. The rotation of crops, the growing of legumes, the use of crops for green manuring, the application of barnyard manure, the methods of preparation and cultivation, and the character of the soil will always be factors which must be taken into consideration when using commercial fertilizer.

THE USE OF LIME.

The use of lime in the agriculture of the South Atlantic States has not been well established. On the principal cotton soils of the section lime has not proved beneficial in increasing the yields of general crops. There are sections in the extreme western part of the Piedmont belt in the Carolinas and Georgia where the failure of red clover indicates the need of lime. There are also numerous small areas of swamp land in the Coastal Plain region that have been drained on which the use of lime has been beneficial. Beyond these local areas so little is definitely known regarding the value of lime in southern agriculture that a full discussion of the subject is omitted. The general conditions under which lime may be used profitably and directions for its use are given in another bulletin of this series.[a]

FARM FERTILIZER PRACTICE IN THE SOUTH ATLANTIC STATES.

In tabulating the results obtained in the investigations in the South Atlantic States it was found desirable to divide the farms studied into two classes, which, for convenience, are denominated Class A and Class B. This division is justified by differences in methods of management and the marked differences in the results obtained.

FARMS OF CLASS A.

The farms of Class A are conducted by men who grow profitable crops and at the same time maintain or increase the fertility of their farms. They practice good crop rotations, deep plowing, and up-to-date methods of management, linked with an intelligent, systematic, and judicious use of fertilizers. No farms are included in this class on which the yields are less than 1,200 pounds of seed cotton, 40 bushels of corn, or 40 bushels of oats to the acre, and other crops in proportion. The principal rotations practiced by these farmers may be mentioned in the order in which they are most frequently used:

Three-year rotation..	First year: Cotton. Second year: Corn, cowpeas, vines turned under. Third year: Oats, cowpeas, vines cut for hay.
Two-year rotation....	First year: Cotton, oats seeded on one-half of land. Second year: Oats, cowpeas, vines cut for hay; corn, cowpeas, vines left on the land.
Three-year rotation..	First year: Cotton, crimson clover seeded in August or September. Second year: Corn. Third year: Oats or wheat, cowpeas, vines cut.
Three-year rotation..	First year: Rye turned under, cotton. Second year: Corn, cowpeas, vines turned under. Third year: Oats, cowpeas, vines cut, rye seeded.
Four-year rotation...	First year: Corn, cowpeas. Second year: Wheat, clover. Third year: Clover. Fourth year: Clover or cotton.

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[a] See Farmers' Bulletin 77, U. S. Department of Agriculture, entitled "The Liming of Soils," 1905.

FARMS OF CLASS B.

The farms of Class B are conducted by farmers who, as a rule, produce only moderately paying crops, and more often decrease than increase the fertility of their farms. In many cases poor judgment is used in buying and using fertilizer, and little consideration is given to rotation and good management. The average yields on these farms are from 600 to 1,200 pounds of seed cotton, 15 to 40 bushels of corn, and 20 to 40 bushels of oats to the acre, and other crops in proportion. Instead of well-planned rotations in which crops are changed in a systematic manner, one crop is often grown on the same land several years in succession without any intervening crop to gather nitrogen or add humus to the soil. The low yields show plainly the effect of poor management, lack of rotation, and poor judgment in applying fertilizer.

Table I gives a summary of the data collected for these two classes of farms in the conduct of investigations. Figures 1 and 2 give this same data in diagrammatic form.

Table I.—*Kinds and quantity of fertilizer constituents used on various kinds of soil in the growing of cotton, corn, and oats on farms of Class A and Class B*[a] *in the South Atlantic States.*

CLASS A FARMS.

Crop.	Kind of soil.	Men furnishing data.	Fertilizer constituents used to the acre.		
			Phosphoric acid.	Ammonia.	Potash.
		Number.	*Pounds.*	*Pounds.*	*Pounds.*
Cotton	Sandy	12	57	25	36
	Sandy loam	30	48	22	27
	Gray loam	23	37	15	15
	Red clay	18	33	12	12
Corn	Sandy	11	43	27	32
	Sandy loam	23	35	23	23
	Gray loam	20	30	18	17
	Red clay	14	30	15	11
Oats	Sandy	3	35	26	24
	Sandy loam	7	30	21	21
	Gray loam	7	36	21	16
	Red clay	8	26	13	12

CLASS B FARMS.

Cotton	Sandy	24	43	21	24
	Sandy loam	51	37	15	16
	Gray loam	14	39	11	14
	Red clay	25	33	12	11
Corn	Sandy	17	20	18	13
	Sandy loam	42	24	14	13
	Gray loam	24	20	9	12
	Red clay	32	27	11	11
Oats	Sandy	6	22	21	12
	Sandy loam	10	24	17	8
	Gray loam	6	11	4	7
	Red clay	6	24	14	14

[a] For explanation of this classification, see pp. 11–12.

The perpendicular lines in the diagrams of figures 1 and 2 represent the different soils previously described. The horizontal lines represent the number of pounds of fertilizer constituents used. The heavy line, the broken line, and the dotted line represent phosphoric acid, potash, and ammonia, respectively. These cross the perpendicular and horizontal lines and show at their points of crossing the average number of pounds of the different fertilizer constituents applied to each crop on the different soils. For example, take the perpendicular line marked "sandy loam soil," under cotton, in the upper left-hand

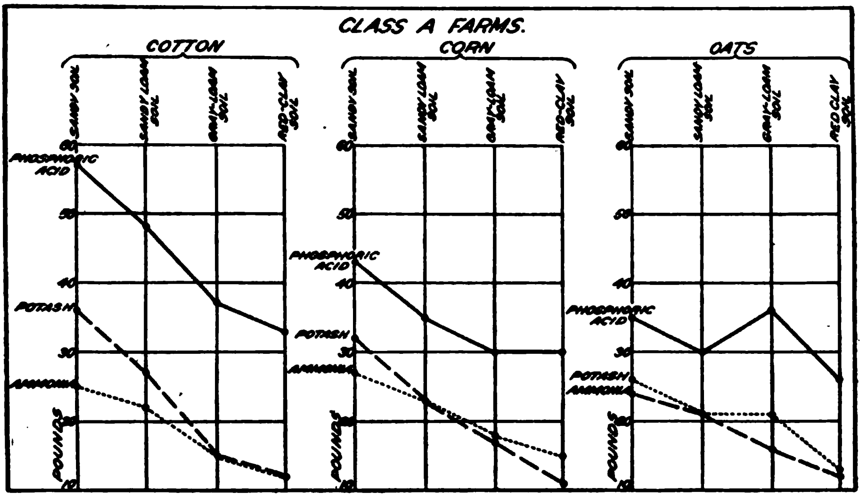

FIG. 1.—Diagram showing the quantity of phosphoric acid, ammonia, and potash used to the acre by farmers of Class A on various kinds of soil for cotton, corn, and oats.

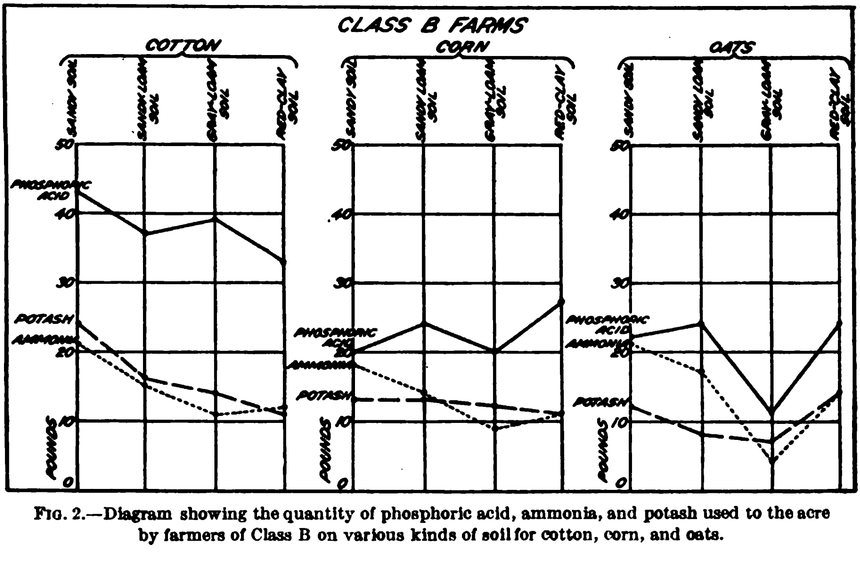

FIG. 2.—Diagram showing the quantity of phosphoric acid, ammonia, and potash used to the acre by farmers of Class B on various kinds of soil for cotton, corn, and oats.

corner of figure 1. This is crossed by the heavy, broken, and dotted lines at 48, 27, and 22, and shows that the best farmers use on sandy loam soils on the average 48 pounds of phosphoric acid, 27 pounds of potash, and 22 pounds of ammonia to the acre for the cotton crop. By carefully looking over the diagrams one can readily see the fertilizer practice of the two classes of farmers on the different soils.

THE FERTILIZER PRACTICE ON FARMS OF CLASSES A AND B.

The most noticeable feature of the summary of the fertilizer practice of the best farmers, as shown in figure 1, is the gradual and almost uniform decline of the heavy, broken, and dotted lines from sandy to red clay soil, especially for cotton and corn. Another noticeable feature in the lines is that the broken lines, representing potash, have a proportionately greater and, in general, a more uniform decline than the heavy and dotted lines, representing phosphoric acid and ammonia, respectively.

The lines for ammonia decline from sandy to red clay soil the least of the three, except in the case of potash for oats. This smaller variation in the quantity of ammonia used to the acre for cotton and corn on the various soils might be expected, as the percentage of nitrogen in different soils on which similar rotations of crops are practiced probably varies less than the percentage of either phosphoric acid or potash.

The variation in the quantity of both ammonia and phosphoric acid used by the best farmers for oats on the different soils is very irregular. There are, however, several good reasons why this variation occurs. First, oats are not considered an important crop, except in certain localities, and farmers have paid less attention to the fertilizer requirements of oats than they have to those of cotton and corn. Second, the oat crop is grown less on sandy than on other soils, and consequently very little data could be obtained concerning the fertilization of this crop on sandy soil. Third, quite a number of the best farmers on all soils plant oats after well-fertilized crops of corn and do not use any fertilizer when planting, but top-dress later with nitrate of soda only.

A glance at the table and lines representing the fertilizer practice of farmers of Class B will show that no such gradual variation in the quantity of plant food used to the acre for the same crops on different soils occurs as in the practice of the best farmers. These farmers, as a rule, have paid little attention to the kind and proportion of fertilizer they use. A good illustration of the attention which many farmers give to the proportion in which the fertilizer constituents are used is afforded by the farmer who, after fertilizing his cotton and tobacco crops, took all the odds and ends of fertilizing materials on hand and mixed them together for the corn crop. Under conditions of this kind the fertilizer practice of such farmers could hardly be expected to be similar to that of the best farmers, except by accident.

In comparing the fertilizer practice of the best (Class A) and second-best (Class B) farmers, it will be noticed that the greatest actual variation in the number of pounds to the acre of any one fertilizer constituent is found in the case of phosphoric acid. It will also be noticed that the least variation occurs in the quantity of ammonia used, while the variation in the quantity of potash is between the two extremes. A further study of the diagrams shows that the greatest general variation in quantity of all the fertilizer constituents between the two classes of farmers occurs on sandy soil, and the least, or practically no variation, on red clay soil.

In the study of fertilizer practice it was found that nearly all of the best farmers mix their fertilizers at home and adjust the different fertilizer constituents to suit the needs of the crop and soil. Farmers of Class B, on the contrary, generally take what the fertilizer manufacturers offer for sale regardless of the proportion in which the fertilizer constituents are supplied.

One of the most common grades of fertilizer put on the market in the South at present is one containing 8 per cent of phosphoric acid, 3 per cent of ammonia, and 3 per cent of potash. It happens that this fertilizer contains the three fertilizer constituents in almost exactly the proportion in which they give the best results for cotton on red clay soil under fairly good methods of rotation. The average farmer accepts the fertilizer mixtures put up by the manufacturer and so fails to secure the fertilizer constituents in proper proportion for the different crops, except on red clay soil.

But why is it that the best farmers on red clay soil get 1,200 pounds of seed cotton, 40 bushels of corn, and 40 bushels of oats to the acre, while the farmers of our second class produce only about two-thirds these quantities, in spite of the fact that both use approximately the same amounts of the different fertilizer constituents? The answer to this question suggests the most important part of successful farming in these States. The difference in yields obtained by the two classes of farmers on like soils, fertilized alike, can only be accounted for by a difference in rotation and management. When the same or similar methods of rotation, preparation, cultivation, and management are put into practice by these two classes of farmers, then, and not until then, will their crops yield alike.

THE FERTILIZING OF CROPS.

The quantities of the different fertilizer constituents and the fertilizer formulas suggested in the following pages are based on the best farm practice, as previously described, coordinated with the results of experiment-station work and with fertilizer tests made by practical farmers in many sections of the South Atlantic States. The combinations and quantities of fertilizing materials recommended in the following pages for the different crops and soils may not always be the most economical and profitable to use. The fertilizer constituents are, however, in the best proportion that can be suggested from the data available, and they may be safely used for present crop production and as a basis for further investigation. They are intended to meet conditions of rotation similar to those of the best farmers, previously described. On farms where the rotations are different and where the grades of soil are between those previously described, the farmer, after carefully studying his conditions, should adjust the fertilizer constituents to suit the needs of his soil and cropping system. Generally, as soil conditions are improved, the quantity of fertilizer necessary to use for a given crop yield can be considerably reduced.

Table II shows in concrete form the total number of pounds of the different fertilizer constituents recommended for cotton, corn, oats, and wheat on each of the more common kinds of soils of the Southeast.

TABLE II.—*Quantities of fertilizer constituents suggested for crops on various kinds of soil under good conditions of rotation and management. The fertilizer constituents are quoted in the terms and in the order commonly used in the Southeastern States.*

Crop.	Kind of soil.	Fertilizer constituents suggested to the acre.		
		Phosphoric acid.	Ammonia.	Potash.
		Pounds.	*Pounds.*	*Pounds.*
Cotton	Sandy	58	26	36
	Sandy loam	50	22	30
	Gray loam	40	16	18
	Red clay	34	13	13
Corn	Sandy	36	26	40
	Sandy loam	34	22	34
	Gray loam	30	18	24
	Red clay	26	16	16
Oats	Sandy	36	24	30
	Sandy loam	30	22	25
	Gray loam	24	20	18
	Red clay	20	18	16
Wheat	Sandy loam	28	20	18
	Gray loam	24	18	14
	Red clay	20	16	10

In making up the total quantity of the different fertilizer constituents suggested in Table II for the various crops, fertilizing materials of different availability should be used. Nitrogen should be obtained from readily or slowly available sources, or both, as indicated in the fertilizer mixtures suggested for each crop. Phosphoric acid and potash may be obtained from any of the standard materials.

In Table III are listed a number of standard fertilizing materials that may be used in compounding fertilizer. These materials can usually be obtained from wholesale dealers, and in many cases from retail dealers.

TABLE III.—*Kinds of fertilizers commonly used and the approximate quantity of fertilizing constituents in 100 pounds of each.*

Fertilizing material.	Availability of plant food.	Kinds and quantity of fertilizer constituents in 100 pounds of fertilizer.		
		Phosphoric acid.	Ammonia.[a]	Potash.
		Pounds.	*Pounds.*	*Pounds.*
Nitrate of soda	Readily available		18 to 19	
Fish scraps	Medium availability	6 to 10	8 to 11	
Dried blood	do		13 to 15	
Cotton-seed meal	do	1 to 2	6.5 to 8	1 to 1.5
Slaughterhouse tankage	do	7 to 11	8 to 12	
Acid phosphate	Readily available	13 to 16		
Basic slag	Medium availability	15 to 17		
Ground bone	Slowly available	22 to 25	2 to 4	
Raw rock phosphate[b]	Very slowly available	26 to 36		
Muriate of potash	Readily available			48 to 52
Kainit	do			12 to 13
Sulphate of potash[c]	do			46 to 50

[a] Multiply ammonia by 0.82 to obtain its equivalent in nitrogen.

[b] This material should be used only when the soil is well filled with humus.

[c] Sulphate of potash may be used to best advantage for potatoes, tobacco, melons, onions, peaches, and other fruits.

FERTILIZING COTTON.

By practicing good rotations the best farmers have their soil fairly well supplied with humus, and consequently find it a good practice to apply all the fertilizer several days before planting. However, on soils very deficient in humus, farmers find that it is more profitable to apply about one half of the fertilizer before planting and retain the other half to be used as a side application about the middle of June.

The fertilizer may be applied either with a distributer or by hand. The chief aim of the best farmers is to get it scattered over a surface at least 6 inches broad and well mixed with the soil. It has been found that an even distribution of the fertilizer over a surface 6 or 8 inches broad is necessary to induce an early and continuous growth of cotton.

On farms where a heavy crop of crimson clover, vetch, or some other legume is turned under as a green manure for the cotton crop, no ammonia need be used in the fertilizer. But when legumes are grown less often and practically all are cut for hay, as indicated in the rotations of the best farmers, the fertilizer should carry about as much ammonia as suggested in Table IV. Farm practice has shown that it is best to use a readily available fertilizing material to furnish about one-third of the total ammonia. The other two-thirds may be supplied from any of the other nitrogenous materials specified in Table III. The number of pounds of the three essential fertilizer constituents and the mixtures given for furnishing these constituents suggested in Table IV are to be used under conditions of rotation similar to those practiced by farmers of Class A.

TABLE IV.—*Quantity and composition of fertilizer mixtures suggested for application to each acre of cotton grown on various kinds of soil.*

Fertilizing material.	Quantity of each constituent.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY SOIL—FIRST SUGGESTION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 16 per cent	350	56.0		
Cotton-seed meal, 1-7.5-1 per cent [a]	240	2.4	18.0	2.4
Nitrate of soda, 18 per cent	45		8.1	
Muriate of potash, 50 per cent (Or 272 pounds of 12.5 per cent kainit.)	68			34.0
Total		58.4	26.1	36.4
SANDY SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	415	58.1		
Dried blood, 14 per cent [b]	125		17.5	
Nitrate of soda, 18 per cent	50		9.0	
Muriate of potash, 50 per cent (Or 288 pounds of 12.5 per cent kainit.)	72			36.0
Total		58.1	26.5	36.0
SANDY LOAM SOIL—FIRST SUGGESTION.				
Acid phosphate, 16 per cent	300	48.0		
Cotton-seed meal, 1-7.5-1 per cent [a]	215	2.2	16.1	2.2
Nitrate of soda, 18 per cent	35		6.3	
Muriate of potash, 50 per cent (Or 224 pounds of 12.5 per cent kainit.)	56			28.0
Total		50.2	22.4	30.2
SANDY LOAM SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	360	50.4		
Dried blood, 14 per cent [b]	115		16.1	
Nitrate of soda, 18 per cent	35		6.3	
Muriate of potash, 50 per cent (Or 240 pounds of 12.5 per cent kainit.)	60			30.0
Total		50.4	22.4	30.0
GRAY LOAM SOIL—FIRST SUGGESTION.				
Acid phosphate, 16 per cent	250	40.0		
Cotton-seed meal, 1-7.5-1 per cent [a]	130	1.3	9.8	1.3
Nitrate of soda, 18 per cent	35		6.3	
Muriate of potash, 50 per cent (Or 136 pounds of 12.5 per cent kainit.)	34			17.0
Total		41.3	16.1	18.3
GRAY LOAM SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	285	39.9		
Dried blood, 14 per cent [b]	75		10.5	
Nitrate of soda, 18 per cent	30		5.4	
Muriate of potash, 50 per cent (Or 144 pounds of 12.5 per cent kainit.)	36			18.0
Total		39.9	15.9	18.0
RED CLAY SOIL—FIRST SUGGESTION.				
Acid phosphate, 16 per cent	210	33.6		
Cotton-seed meal, 1-7.5-1 per cent [a]	120	1.2	9.0	1.2
Nitrate of soda, 18 per cent	25		4.5	
Muriate of potash, 50 per cent (Or 100 pounds of 12.5 per cent kainit.)	25			12.5
Total		34.8	13.5	13.7
RED CLAY SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	245	34.3		
Dried blood, 14 per cent [b]	65		9.1	
Nitrate of soda, 18 per cent	25		4.5	
Muriate of potash, 50 per cent	26			13.0
Total		34.3	13.6	13.0

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[a] Equals 1 per cent of phosphoric acid, 7.5 per cent of ammonia, and 1 per cent of potash.

[b] Slaughterhouse tankage may be substituted for dried blood if, on the basis of the weight of plant food contained, it is cheaper.

In Table V the quantities, given in pounds, of mixed fertilizers, of the analysis given in the last three columns of the table, are equivalent in total pounds of fertilizer constituents to those recommended to be used in the mixtures given in Table IV. Thus, 725 pounds of 8:3.6:5 goods contain the same quantities of phosphoric acid, ammonia, and potash as the mixtures given for cotton on sandy soil in Table IV.

TABLE V.—*Quantity and composition of a mixed fertilizer of definite analysis suggested for application to each acre of cotton grown on various kinds of soil.*

Kind of soil.	Quantity of mixed fertilizer.	Composition of mixture.		
		Phosphoric acid.	Ammonia.	Potash.
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*
Sandy	725	8.0	3.6	5.0
Sandy loam	625	8.0	3.5	4.8
Gray loam	500	8.0	3.6	3.6
Red clay	425	8.0	3.06	3.06

FERTILIZING CORN.

A method of fertilizing corn widely used, and apparently worthy of commendation, in the South Atlantic States is to plant the corn below the level of the soil and cultivate once or twice before making the first application of fertilizer. Some farmers make this application on each side of the row, while others think it is practically as beneficial and more economical to apply to one side only. The prevailing practice is to make the first application of fertilizer when the corn is about 2 feet high and use two-thirds of the total phosphoric acid and potash and one-half of the nitrogen that is to be used on the crop. The fertilizer is distributed evenly over a furrow at least 4 inches broad, 3 or 4 inches deep, and about 8 inches from the row of corn. The fertilizer is then covered by cultivating the corn shallow.

The second, or last, application of fertilizer, consisting of one-third of the total phosphoric acid and potash and one-half of the nitrogen, is made about the time the corn prepares for tasseling. This application is made on the opposite side of the row from the first, in order to make a uniform distribution of the fertilizer. The corn is usually cultivated for the last time immediately after the fertilizer is distributed.

For the first application of fertilizer, materials furnishing nitrogen or ammonia in a slowly available form, such as cotton-seed meal, dried blood, and tankage, should be used. For the second application it is preferable to use nitrogen in a readily available form, like nitrate of soda. The amount of nitrogen necessary to produce a good corn crop will depend upon the rotation. When a heavy crop of crimson clover is turned under as a green manure for corn the nitrogen may be economically omitted from the fertilizer.

Table VI shows the quantities of the essential fertilizer constituents and fertilizer mixtures suggested for corn on the different soils under conditions of rotation such as the best farmers practice.

TABLE VI.—*Quantity and composition of fertilizer mixtures suggested for two applications to each acre of corn grown on various kinds of soil.*

Fertilizing material.	Quantity suggested.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY SOIL—FIRST APPLICATION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Cotton-seed meal, 1-7.5-1 per cent [a]	175	1.7	13.1	1.7
Acid phosphate, 16 per cent	140	22.4		
Muriate of potash, 50 per cent	54			27.0
Total		24.1	13.1	28.7
SANDY SOIL—SECOND APPLICATION.				
Acid phosphate, 16 per cent	75	12.0		
Nitrate of soda, 18 per cent	75		13.5	
Muriate of potash, 50 per cent	24			12.0
Total		12.0	13.5	12.0
Total, first and second applications		36.1	26.6	40.7
SANDY LOAM SOIL—FIRST APPLICATION.				
Acid phosphate, 16 per cent	125	20.0		
Cotton-seed meal, 1-7.5-1 per cent [a]	150	1.5	11.2	1.5
Muriate of potash, 50 per cent	43			21.5
Total		21.5	11.2	23.0
SANDY LOAM SOIL—SECOND APPLICATION.				
Acid phosphate, 16 per cent	75	12.0		
Nitrate of soda, 18 per cent	60		10.8	
Muriate of potash, 50 per cent	24			12.0
Total		12.0	10.8	12.0
Total, first and second applications		33.5	22.0	35.0
GRAY LOAM SOIL—FIRST APPLICATION.				
Acid phosphate, 16 per cent	120	19.2		
Cotton-seed meal, 1-7.5-1 per cent [a]	120	1.2	9.0	1.2
Muriate of potash, 50 per cent	30			15.0
Total		20.4	9.0	16.2
GRAY LOAM SOIL—SECOND APPLICATION.				
Nitrate of soda, 18 per cent	50		9.0	
Acid phosphate, 16 per cent	60	9.6		
Muriate of potash, 50 per cent	16			8.0
Total		9.6	9.0	8.0
Total, first and second applications		30.0	18.0	24.2
RED CLAY SOIL—FIRST APPLICATION.				
Acid phosphate, 16 per cent	155	24.8		
Cotton-seed meal, 1-7.5-1 per cent [a]	110	1.1	8.2	1.1
Muriate of potash, 50 per cent	32			16.0
Total		25.9	8.2	17.1
RED CLAY SOIL—SECOND APPLICATION.				
Nitrate of soda, 18 per cent	45		8.1	
Total, first and second applications		25.9	16.3	17.1

[a] Equals 1 per cent of phosphoric acid, 7.5 per cent of ammonia, and 1 per cent of potash.

The amount of fertilizer constituents for corn on various kinds of soil suggested in Table VI may be secured by using the quantities of mixed fertilizer of the analysis given in Table VII.

TABLE VII.—*Quantity and composition of a mixed fertilizer of definite analysis suggested for application to each acre of corn grown on various kinds of soil.*

Kind of soil.	Quantity of mixed fertilizer.	Composition of mixture.		
		Phosphoric acid.	Ammonia.	Potash.
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*
Sandy	450	8.0	5.75	8.9
Sandy loam	425	8.0	5.2	8.0
Gray loam	375	8.0	4.8	6.4
Red clay	325	8.0	4.92	4.92

FERTILIZING OATS.

There are two methods of fertilizing oats applicable to different conditions which can be recommended. The first method is suited to all soils, while the second must vary with the farming conditions and the soil.

The first method consists of applying the phosphoric acid and potash to fall oats at the time of seeding, the ammonia being retained to apply in the spring after the danger of frost has passed. Immediately after the fertilizer is applied in the spring the oats are harrowed with a light smoothing harrow to cover the fertilizer.

The second method is applicable only to farms where the oat crop follows some cultivated crop that has been well fertilized. In many cases of this kind oats are seeded in the fall without fertilizer, but the following spring an application of nitrate of soda is made. This method should be practiced only when it is reasonably certain that there is sufficient available phosphoric acid and potash in the soil to grow a good crop of oats. Often the effect of the nitrate is practically lost on account of an insufficient supply of the mineral elements.

The ammonia used in the fertilizer for this crop is usually supplied from two sources, one readily available and the other slowly available. Nitrate of soda is nearly always used to supply readily available nitrogen. The quantities of fertilizer constituents and fertilizer mixtures given in Table VIII are intended to be used where a small growth of cowpea vines or the stubble of a cowpea crop is turned under. When a heavy growth of pea vines is turned under all the ammonia in the fertilizer may be dispensed with.

TABLE VIII.—*Quantity and composition of fertilizer mixtures suggested for fall and spring applications to each acre of oats grown on various kinds of soil.*

Fertilizing material.	Quantity suggested.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY SOIL—FALL APPLICATION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 16 per cent	225	36.0		
Muriate of potash, 50 per cent	60			30.0
Total		36.0		30.0
SANDY SOIL—SPRING APPLICATION.				
Cotton-seed meal, 7.5 per cent	200		15.0	
Nitrate of soda, 18 per cent	50		9.0	
Total			24.0	
Total, fall and spring applications		36.0	24.0	30.0
SANDY LOAM SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	190	30.4		
Muriate of potash, 50 per cent	50			25.0
Total		30.4		25.0
SANDY LOAM SOIL—SPRING APPLICATION.				
Dried blood, 14 per cent	100		14.0	
Nitrate of soda, 18 per cent	45		8.1	
Total			22.1	
Total, fall and spring applications		30.4	22.1	25.0
GRAY LOAM SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	150	24.0		
Muriate of potash, 50 per cent	36			18.0
Total		24.0		18.0
GRAY LOAM SOIL—SPRING APPLICATION.				
Dried blood, 14 per cent	80		11.2	
Nitrate of soda, 18 per cent	50		9.0	
Total			20.2	
Total, fall and spring applications		24.0	20.2	18.0
RED CLAY SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	125	20.0		
Muriate of potash, 50 per cent	32			16.0
Total		20.0		16.0
RED CLAY SOIL—SPRING APPLICATION.				
Cotton-seed meal, 7.5 per cent	170		12.8	
Nitrate of soda, 18 per cent	30		5.4	
Total			18.2	
Total, fall and spring applications		20.0	18.2	16.0

FERTILIZING WHEAT.

The wheat crop was not considered in the summary of fertilizer practice because it is very seldom grown on any other than gray loam and red clay soils. At present prices, however, wheat could be profitably grown on some of the heavy sandy loam soils.

The fertilizer may be applied to this crop as to oats. The first method given for fertilizing oats, namely, the application of phosphoric acid and potash in the fall and of nitrogen in the spring, is more generally suited for wheat. When phosphoric acid and potash are supplied in the fertilizer and sufficient barnyard manure is available to give the land an application of 10 tons to the acre, no ammoniated fertilizer need be applied in the spring. Likewise, when the wheat crop follows a good crop of clover or cowpeas all, or nearly all, the ammonia in the fertilizers applied may be omitted. When the wheat field is seeded to clover or clover and grass and left down for hay, more phosphoric acid and potash should be used than when no hay crop follows. The quantities of the different fertilizer constituents given in Table IX are intended for wheat under fairly good farming conditions and where the land is not to be seeded to clover and grass.

TABLE IX.—*Quantity and composition of fertilizer mixtures suggested for fall and spring applications to each acre of wheat grown on various types of soil.*

Fertilizing material.	Quantity suggested.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY LOAM SOIL—FALL APPLICATION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 16 per cent	175	28.0		
Muriate of potash, 50 per cent	36			18.0
Total		28.0		18.0
SANDY LOAM SOIL—SPRING APPLICATION.				
Nitrate of soda, 18 per cent	110		19.8	
Total			19.8	
Total, fall and spring applications		28.0	19.8	18.0
GRAY LOAM SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	150	24.0		
Muriate of potash, 50 per cent	28			14.0
Total		24.0		14.0
GRAY LOAM SOIL—SPRING APPLICATION.				
Nitrate of soda, 18 per cent	100		18.0	
Total			18.0	
Total, fall and spring applications		24.0	18.0	14.0
RED CLAY SOIL.				
Acid phosphate, 16 per cent	125	20.0		
Muriate of potash, 50 per cent	20			10.0
Dried blood, 14 per cent	114		15.9	
Total		20.0	15.9	10.0

FERTILIZING COWPEAS.

The results of farm practice indicate that it is not profitable to fertilize the cowpea crop when grown on good soil or when it follows crops that have been fertilized heavily. On the other hand, when the cowpea is planted on poor soil it should receive some fertilizer, the kind and quantity depending on the kind of soil and how badly it is run down.

On ordinary poor sandy, sandy loam, and gray loam soils 200 pounds of acid phosphate and 50 to 100 pounds of kainit to the acre have been the most profitable kinds and quantities of fertilizing materials used.

On red clay soil 200 pounds of acid phosphate to the acre have produced the most profitable crops.

When the soil is very badly run down a small quantity of cottonseed meal, dried blood, or some other ammoniated fertilizing material should be added to the mineral fertilizer used. This ammoniated material will be needed only on soils too poor to maintain the plants in good growing condition until they are able to gather nitrogen from the air.

SUMMARY.

(1) Commercial fertilizers are expensive. Accurate information is needed for their economic use.

(2) With a good rotation, deep and thorough tillage, and the use of green manures, legumes, and winter cover crops, the quantity of commercial fertilizers required for a given crop yield can be considerably reduced.

(3) The character of the soil has a marked influence on the quantity and kind of fertilizer it is necessary to use in a good system of farming.

(4) In farm practice there is a gradual increase in the quantity of all the fertilizer constituents required to produce like yields as the proportion of sand in the surface and subsoil increases. The increase is greatest in the quantity of potash necessary, followed by phosphoric acid, and then by nitrogen.

(5) A study of farm practice shows that the best farmers, those referred to in this bulletin as belonging to Class A, obtain yields of 1 to 2 bales of cotton, 40 to 75 bushels of corn, and 40 to 75 bushels of oats on soils where farmers of Class B get but one-half to 1 bale of cotton, 15 to 40 bushels of corn, and 15 to 40 bushels of oats, due to the fact that the best farmers have a better understanding of the use of fertilizers and employ better farm methods.

(6) One of the most common grades of fertilizer on the market in the South Atlantic States at present contains 8 per cent of phosphoric acid, 3 per cent of ammonia, and 3 per cent of potash. This grade of fertilizer is of primary value only for cotton on red clay soil under fairly good methods of rotation. This fertilizer formula needs to be greatly modified for crops on sandy, sandy loam, and gray loam soils, and for all crops other than cotton on red clay soil.

(7) Detailed suggestions are contained in this bulletin on the best method of fertilizing and the most profitable kinds of fertilizer constituents to apply on soils of different character to cotton, corn, oats, wheat, and cowpeas.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 399.

IRRIGATION OF GRAIN.

BY

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1910.

LETTER OF TRANSMITTAL.

U. S. **Department of Agriculture,**
Office of Experiment Stations,
Washington, D. C., April 1, 1910.

Sir: I have the honor to transmit herewith a paper giving practical directions regarding the irrigation of grain, prepared by Walter W. McLaughlin, irrigation engineer, under the direction of Samuel Fortier, chief of irrigation investigations. The data on which this paper is based were collected by the agents of this Office throughout the arid region, and compiled by Professor McLaughlin. It is recommended that the paper be published as a Farmers' Bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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IRRIGATION OF GRAIN.

INTRODUCTION.

As a rule grains are the first crops grown on lands being brought under irrigation, for several reasons. They are food crops and therefore in demand; they require less outlay in preparing the land for irrigation and in seed, and bring quicker returns than most other crops; they do well on virgin soil and help to put the soil in condition for other crops; and in most sections their need for irrigation corresponds to the period of greatest water supply. Most of the streams of the arid region are torrential, having a flood period in spring and early summer, and low water in the late summer. The grains make their growth during this flood period, and are ready for harvest when the streams subside. They are therefore preeminently the new-land crops. As irrigated regions develop, special crops of high values are introduced, water is stored to meet their long-season demands, and the grains are displaced to a considerable extent.

In the regions which have been irrigated for many years, such as Colorado and Utah, grain is used in rotation with other irrigated crops. In the vicinity of Longmont, Colo., the prevailing rotation is alfalfa three years, potatoes or beets three years, wheat or barley two years, and seed back to alfalfa. In that section it is not considered good practice to have grain follow alfalfa, as it makes too heavy straw, while in Utah it is common practice to follow alfalfa with grain. Other rotations differ slightly, but this one may be considered typical. Grain is the least valuable crop in this scheme, and is given the least time.

Clearing and leveling land for the growing of grains under irrigation do not differ from clearing and leveling for other crops. The general subjects of clearing and leveling land are discussed at length in other bulletins,[a] and that discussion will not be repeated here, but this bulletin will be confined to those practices which belong especially to the irrigation of grain.

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[a] U. S. Dept. Agr., Farmers' Buls. 263, 373.

METHODS OF APPLYING WATER.

The fact that grain crops cover the entire surface restricts the methods which can be used for its irrigation. They must be irrigated by some form of flooding or in small furrows in which the grain can grow. In general, flooding is considered less desirable than other methods wherever any other method can be used, because the wetting of the entire surface increases the area exposed to evaporation, and causes soils of some types to puddle and bake when exposed to the sun and wind; but these objections to flooding have less weight with grain than with other crops, because it is seldom that grain fields are irrigated after the seed is planted until the grain is 6 or 8 inches high and protects the soil from sun and wind. From the standpoint of the settler, however, flooding is better than other methods, because it requires less preparation of the land for irrigation and the land is smoother for handling.

Probably the most common method of irrigating grain crops is flooding from field ditches, but they are also flooded in strips between levees, called the border method, and in basins formed by dividing a field by levees running both ways, and watered by furrows. These methods are described more in detail in the following pages.

FLOODING FROM FIELD DITCHES.

Flooding from field ditches was the method adopted for irrigating grain in the sections of the arid region first settled, and it is still the prevailing method in those sections. It requires the least preparation of the fields and therefore appeals to the new settler. It can be used on quite rolling ground, since the field ditches can be run along the ridges and the water allowed to flow down the slopes in all directions. On the other hand, it requires more labor in applying water than any other method, and requires a larger stream of water than the furrow method, although one man can not use so large a stream as he can in either the border or check method. On steep land flooding is liable to cause cutting, and in cold, damp seasons flooding is said to aggravate trouble from rust.

The method consists in running small ditches through the fields and running the water from these ditches over the surface without other direction than is given to it by the irrigator with his shovel.

The direction of sowing if the drill is used is of importance where land is to be flooded. The miniature drill furrows can be taken advantage of where they run with the slope to lead water quickly over the land in flooding, and when it is desirable to check the rate of flow upon the soils which have a rather steep slope or which do not absorb water readily, the furrows can be run across the slope. This device will be of considerable assistance to farmers who flood their land and is worth a trial. The cost of drilling will vary from 35 to 70 cents per acre, and will probably average 45 cents.

The proper location of the field ditches depends upon the lay of the land. On rolling land they will be run on the ridges, and the water will flow down the slopes. On land with a uniform slope, or a slope in one direction, they will be laid out in one direction and at regular intervals, the most common practice being to run a supply ditch down the slope along the margin of the field and from this run ditches through the field across the slope with just enough grade to carry the water. The water flows from the lower bank of each ditch down the slope to the next ditch (fig. 1). Another arrangement is to run the supply ditch across the slope and from this run field ditches down the slope and turn water out of both sides, letting it run down the slope, as shown in figure 2.

On rolling land the proper location for the field ditches can be determined by eye, but on nearly level land it is necessary sometimes to have the lines run with some sort of a level, either some homemade device, such as a carpenter's level on a tripod or on a straight edge with a leg at each end, or a triangle with plumb bob, or with a regular surveyor's level. After cultivating a field for a few years, the farmer learns the slopes so thoroughly that he can run his ditches by eye without difficulty.

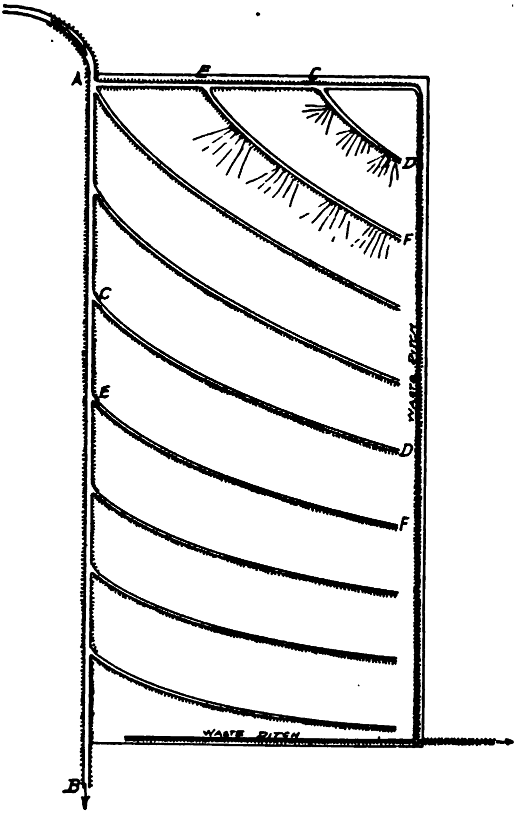

FIG. 1.—Flooding from field laterals.

The grade given the ditches varies with the soil. It should not be steep enough to allow the water to cut out the bottom, and where ditches must be run down slopes, checks and drops should be put in rather than putting all the slope in the ditch. Where the field ditches are run across the slope they should be as nearly level as they can be and carry the water, in order that the water when checked up for that purpose may flow evenly over the ditch bank onto the land. The usual slopes are 1.5 to 6 inches per 100 feet, depending upon the class of soil. Heavy soils will permit of more slope or fall than lighter ones.

The field ditches running across the slope are placed at more or less regular intervals of 150 to 400 feet, according to the slope and the nature of the soil. On light, sandy soil they must be placed close together, or the land near a ditch will get too much water before the land farther away has received enough, but on heavy soils the ditches may be placed farther apart, as the water soaks in more slowly. The general tendency is to place them too far apart, and this should be guarded against. The closer the ditches are spaced the more even the watering, but putting in more ditches than are necessary not only makes an unnecessary expense for construction, but withdraws the land occupied by the ditches from cultivation. The advantages and disadvantages of different spacings must be weighed in deciding upon it, but it is well to guard against trying to run water long distances from the ditches.

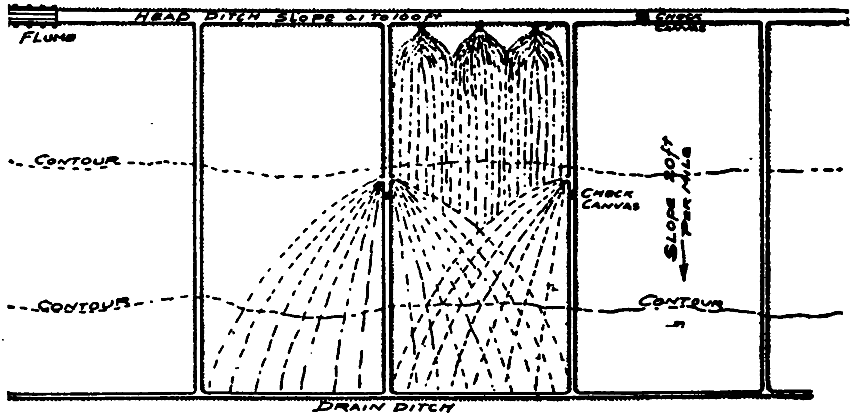

FIG. 2.—Flooding from head ditches in northern Colorado.

Some farmers use the same ditches as long as a field remains in grain, but it is more common to fill the ditches each year before harvest by turning the banks in with a plow or with an implement made for this purpose from disks (fig. 3). This makes it easy to run harvesting machinery over them and kills any weeds that may be growing on the banks. The location of the ditches can be seen closely enough for use another year if it is desired to use the same lines.

The first-mentioned method was formerly used almost exclusively in the grain and potato fields of eastern Idaho, but the farmers have long since discarded it, and now make new ditches every year. These can be made very cheaply with plow and go-devil. Harvesting and spring plowing are done much more economically when the ditches are not in the way.

Making field ditches.—By field ditches is meant those which distribute the water over the fields, rather than the supply ditches which bring the water to the fields. The location and construction of the permanent farm ditches are discussed in other bulletins[a] and will not be considered here. Field ditches are most commonly made with the ordinary plow and some sort of crowder (fig. 4), or with a double moldboard plow or lister. On land with considerable slope the ditches should run across the slope, and all the soil from a ditch should be thrown on the lower side. This can be done by putting additional wings on the plow to throw the soil farther out of the ditch, and by running one side of the crowder flat against the upper side of the furrow and crowding all the earth in one direction. On nearly level land the excavated soil should be thrown on both sides. This is done by plowing out a dead furrow or by plowing a furrow with a double moldboard plow and clearing this out and smoothing the banks by hand with a shovel or by pushing the loose soil out with a crowder. The crowder is a V-shaped drag made of 2 by 12 inch

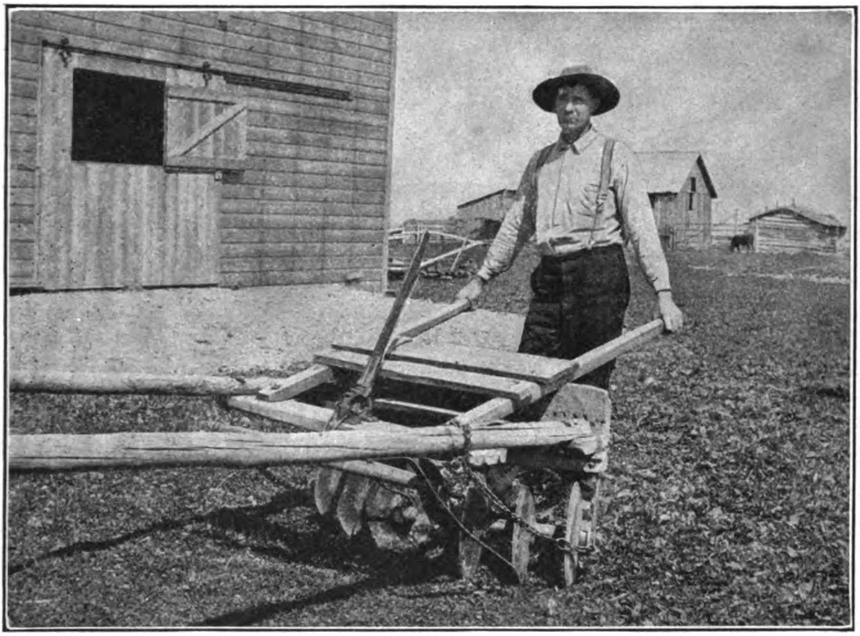

FIG. 3.—Disks set for turning in field ditches.

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[a] U. S. Dept. Agr., Farmers' Buls. 158, 263, 373.

planks, 10 or 12 feet long, steel shod, joined at one end and beveled to make a sharp cutting edge (fig. 4). The sides are hinged so that the width of the crowder is adjustable. Two to four furrows are plowed, and then the crowder is used to push the soil out. Ditches are made 2 to 4 feet wide on top and 8 to 16 inches deep. They must be partly above the natural surface of the ground in order that the water may be run out over the surface. Dams are placed in the ditches to hold the water up and run it over the lower banks. Usually twice through a ditch with the crowder will put it in good shape, and a man with a team can construct 1 to 1.5 miles of ditch in a day in a sandy loam soil.

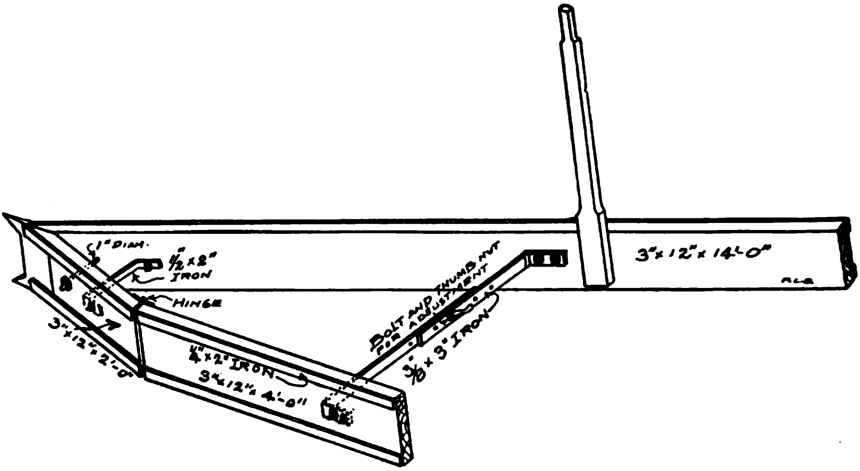

FIG. 4.—Adjustable "V" scraper or crowder.

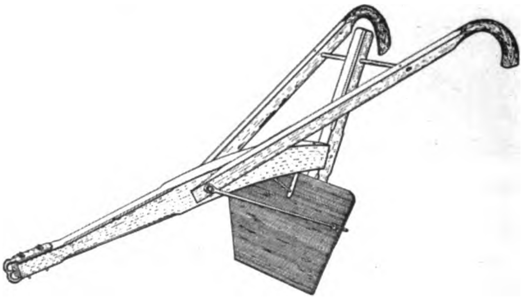

FIG. 5.—Dammer used in cleaning and damming field laterals.

Often dams for turning the water from field ditches are put in when the ditches are made. Sometimes they are made of earth scraped from the bottom of the ditch with a dammer (fig. 5) and dumped in piles at the desired intervals. Sometimes the earth is taken from the bottom of the ditch immediately below the dams and when the dams are broken is washed back into the places from which it was taken. Manure is often used, being placed in piles in the ditch or alongside before irrigation begins. The canvas dam is, however, probably the most common form of dam used for turning water out of field ditches. It is inexpensive, easily made, and convenient to handle. It consists simply of a rectangular piece of canvas long enough to reach well across the ditch, with one edge fastened to a timber or pole, which is placed across the ditch. As a rule, there are no permanent structures in the field ditches in grain fields irrigated by flooding. Gates are sometimes put in the supply ditches, but often the water is held up in the supply ditch by temporary dams and turned out through cuts in the ditch bank. Water is run in one or more of the field ditches at a time, depending upon the size of the stream delivered to the irrigator. The usual stream run in a ditch is about 1 second-foot, or 40 to 50 inches. If water is delivered in a stream of 2 or 3 second-feet this stream should be divided among as many field ditches. If the land is in good shape, one man can look after two or three ditches, and to make the best use of his time he should have as large a stream as he can handle. This should be kept in mind in making agreements for water, and where the farmer's water right does not call for as large a stream as he can handle, arrangements for rotation with his neighbors should be made, in order that each may have a good working stream.

Water is turned into one or more ditches and allowed to flow down to the first dam, where it is held up and made to overflow the lower bank of the ditch and flow over the field to the next ditch. When this section has received enough water the dam is broken and the stream flows down to the next dam, and the operation is repeated until the whole field is covered. With as large a stream as he can handle one man can water 10 to 25 acres in a day of twenty-four hours.

FLOODING BETWEEN BORDERS.

A modification of the flooding method just described is flooding between levees or borders. This requires more preparation of the land before irrigating than does flooding from field ditches, but requires less labor in applying the water. A head ditch or supply ditch is run across the upper end of the field, running across the greatest slope. From this head ditch parallel levees or borders are run down the slope at intervals of 40 to 60 feet, dividing the field into a series of lands (fig. 6). Each land is made level between the borders, so that water can be made to flow down the slope in a sheet extending across the land from border to border. If the field is properly prepared the water requires no attention from the irrigator after he has turned it into a border until that part of the field has received enough water, when it must be shut off.

If the field is a long one a supply ditch runs down the slope and from this head ditches are run across the lands at intervals (fig. 6). The distance which water can be run down a land between head ditches depends upon the character of the soil. If the soil is very light the lands must be short or the upper ends will get too much water; if the soil is heavy they may be longer. Lands vary in length from 500 to 1,000 feet.

The borders dividing the lands may be more or less permanent. In some places they are mere back furrows, while in other places they are permanent embankmants. They may be made by plowing several furrows and crowding the loose soil into a ridge with a ridger (fig. 7), or they may be made with a scraper. In some sections they are made when the land is being leveled. A scraper is drawn across the slope, taking soil from the high points and dumping it in the levees.

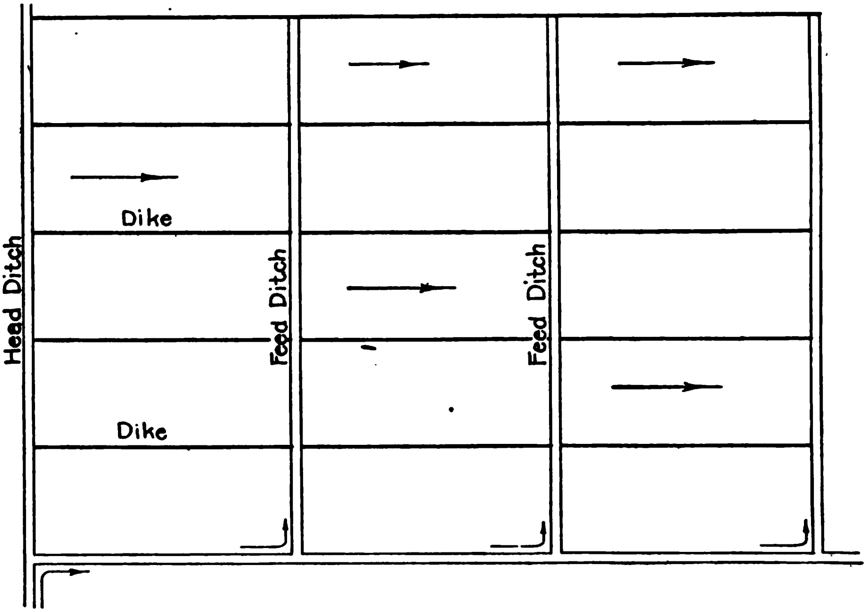

FIG. 6.—Layout of field for flooding between borders.

These are afterwards smoothed down with a drag. They are made broad and low, so that the crop can be planted all over them and machinery can be run over them without difficulty.

The head ditches are larger than the field ditches used in flooding, as larger streams are used. A man should have a stream of at least 2 or 3 cubic feet per second and can handle one twice as large, as he has to give little attention to the water except to turn it into the lands. The ditches are usually permanent, with gates where the water is turned into the lands.

This method is adapted to both light and heavy soils. If the soil is light a large stream can be forced over the surface quickly before it has time to soak in too deep, and if the soil is heavy a smaller stream may be used and be kept running for a long enough time to allow it to soak in sufficiently. As the irrigator does not have to watch the water, this slower process is not a great drawback.

This system is used to a considerable extent in the Southwest, but is not generally used elsewhere. It seems to be becoming more popular on account of the saving of labor in applying water.

FLOODING IN CHECKS.

For flooding in checks a field is divided into a series of basins by levees running across the field in both directions. The checks are sometimes made rectangular, and sometimes the levees running across the slope are run on contours. The rectangular checks are adapted to land which is nearly level or has a uniform slope, so that contour lines would be nearly straight. Rectangular checks are better than contours where they can be used, because they conform to field lines and present less obstruction to the operation of farm machinery.

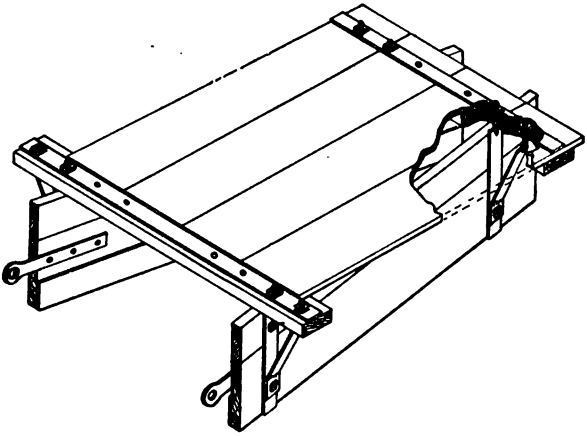

FIG. 7.—Adjustable ridger.

The distance between the levees running across the slope of the field is governed principally by the slope. The fall between two levees must be less than the height of the levees, so that water will be held high enough to cover the surface completely. Levees must not be too high to be crossed by harvesting machinery, and consequently on land of considerable slope they must be placed close together. For this reason this system can not be used on land which has much slope, as the levees would be too close together to be practicable.

The size of the checks is also governed to some extent by the slope, but to a considerable extent by the nature of the soil and the size of the head of water available. While large checks are used in places, the tendency is to make them smaller, the usual sizes being 1 to 2 acres in a check.

When the small checks are used on nearly level land the lines for the levees need not be run with an instrument, as the slope in the distance between levees is not enough to make their exact location important. On more sloping ground it will be necessary to determine the levels on the field and locate the levees with reference to these.

Broad, low levees over which machinery can be run are best. The crop is seeded all over them, and usually the levees will receive enough water to mature the crop. The levees are built as described for the border method. The attempt is made to make a uniform slope within each check, and the earth is taken from the high places to form the levees.

In some sections the supply ditch is run across the upper end of the field and water is turned from this ditch into the upper check of each series and run from that one through a gate or a cut in the lower levee into the checks below in turn, the usual practice being to fill the highest one first and use the lowest one to catch the waste from the others. Sometimes, however, the lowest one is filled first and those above in turn. Another system is to make supply ditches on alternate levees running down the slope and fill the checks on both sides from these ditches. If the slope is too great to run water in this way without washing, drops should be put in the ditches. Combined gates and drops can be used to good advantage.

The preparation of land for irrigation by this method is more expensive than for other flooding methods previously described because of the additional levees required. However, the labor of applying water is less than with flooding from field ditches, since it is necessary only to turn the water into the checks and the levees will hold it up, so that the entire surface will be covered. This method is adapted either to light or heavy soils. With light, open soils a large head of water can be turned into a check and forced over it before it has time to soak away near the gate where it is turned in, while with heavy soils it is possible to hold the water on the surface until a sufficient quantity has been absorbed. With this method one man can handle a stream of 5 to 10 second-feet, making it possible to cover his land in a short time.

FURROW OR CORRUGATION IRRIGATION.

The soils in the irrigated section of the Northwestern States are largely of volcanic origin, and puddle when wet and bake and crust when exposed to the sun and wind. For that reason crops are seldom flooded. The common method of irrigating grain and alfalfa is by what is called locally the corrugation method. In this method the water is run in small, shallow furrows, from which it percolates laterally through the soil, but does not run over the surface. A small stream is run for a considerable time in each furrow until the adjacent soil has received enough water. It is adapted to heavy soils, which take water slowly, and to considerable slopes, since the furrows can be run across the slopes at any angle which gives the grade required for the desired velocity of water. It is adapted to the use of small streams of water, since water can be run in few or many furrows, according to the size of the stream available.

Feed ditches are run across the slope of the field, while the furrows run down the slope or across it at an angle, according to the steepness of the slope. The ditches should be nearly level, so that when water is held up by the dam it will flow over the lower bank throughout a considerable length of the ditch. In the Twin Falls country in Idaho check boxes are put into the feed ditches, so that water can be held on a series of levels.[a] The check boxes are supplied with flashboards, which hold the water up to any desired height and allow the surplus water to flow over and down the ditch to the next check box. The water is turned out to the furrows through lath boxes placed in the lower bank of the ditch for that purpose. The boxes in the section of a ditch between two check boxes are on a level above the surface of the water when unchecked, but at such a height that when water is held up by flashboards in the check box they will be submerged slightly and will discharge water to the furrows. The boxes increase the cost of preparing the land for irrigation, but decrease the labor required in applying water, and their use makes possible a very even distribution of water. As water is allowed to run in one set of furrows for several hours this system is especially valuable where night irrigation is practiced. Water can be turned into a set of furrows and needs no further attention.

In other sections water is turned out through cuts in the lower bank of the ditch and divided among the furrows by the irrigator with his shovel. This requires constant attention by the irrigator, which is not necessary when the lath boxes are used. In some cases the supply ditch is cut and the water turned directly into the furrows, but in a majority of instances where there is a liability of the soil washing it is the practice to use a distributing ditch in addition to a supply ditch. This distributing ditch is rather shallow, having a width of 1 to 3 feet, and is run below and parallel to the head ditch some 3 to 6 feet distant. The water is turned from the supply ditch into the distributing ditch and from the distributing ditch into the furrows. The advantage of the distributing ditch is found in that if one section of the distributing ditch washes out the water can be readily turned out of this section and used elsewhere until the places washed out have been repaired. It is not common to use the double ditch except at the top of a field.

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[a] See U. S. Dept. Agr., Farmers' Bul. 373, fig. 18.

In Idaho and Washington the furrows are usually made with a furrowing sled, which consists of two or three runners made of logs or 6 by 6 inch timbers, spaced at whatever distance is desired between the furrows, and sharpened at the front end. These will make furrows 3 to 5 inches deep. In grain fields the furrows are made 1.5 to 3 feet apart, depending upon the character of the soil. In Utah furrows are made sometimes with a roller having raised rings on its surface. When the roller is drawn over a field these rings make the furrows and crush the clods, which aids in the even distribution of the water.

The length of furrows is 150 to 600 feet, according to the slope of the land and the nature of the soil. Feed ditches are run across the field at these intervals and take up the waste water from the furrows above them and supply water to those below. The furrows are made just after seeding, so that the crop covers the entire surface.

Preparing a field for irrigation by this method is more expensive than for flooding, but less labor is required for putting on the water. It secures a more even distribution of water, since the furrows, if the field is prepared properly, will carry the water to every point in the field.

This system is not adapted to very open soils, since in them the water will percolate down beyond the reach of plant roots, rather than to the sides, moistening the soil between furrows. It is especially valuable on clay soils, which bake and crack after being wet.

WHEN TO IRRIGATE.

The character of the soil and subsoil has a large influence upon the time of irrigating. A heavy soil with tight subsoil will receive large quantities of moisture and hold it for a long time, making it possible to irrigate heavily and at long intervals. If such a soil is underlaid with gravel the water will drain out and more frequent irrigation will be necessary. The same principle holds with lighter soils. The lighter the soils and the more open the subsoils the more frequently it will be necessary to irrigate. The lighter soils have less water capacity, so that the irrigations should be light and frequent.

The ideal condition seems to be to have sufficient moisture in the soil at the time of seeding to germinate the seed and keep the plants growing until they are large enough to shade the ground when the crop is irrigated. It is irrigated again when the grain is in the boot—that is, when the heads are just beginning to show—and sometimes again when the heads are filling.

In localities having a small winter precipitation or where the evaporation is excessive during the winter months, as is the case along part of the Pacific coast, in New Mexico, Arizona, and a few other localities, the utility of irrigation during the nongrowing season has been demonstrated. Where the water supply is deficient, irrigation at a time when the water can be obtained, either in the winter or the spring before planting, is of service to store moisture in the soil for the plant's use later in the season. Winter irrigation is not well understood or its benefits realized as would be the case were the practice more extensive. Irrigation prior to planting is of great service in localities with a limited water supply where such supply is required by other and more profitable crops later in the season.

In winter irrigation the land is irrigated once or twice before heavy freezing weather, the first irrigation two weeks to a month prior to the last one, which should occur just before heavy frost. The better method of winter irrigating is by the furrow method, unless the land can be harrowed after the last irrigation, as a mulched surface during the winter is desired, that the winter precipitation may enter the soil readily. Sufficient water should be applied to saturate the soil to a depth of 4 to 6 feet, provided the soil is rather deep and not underlaid near the surface with porous material such as sand and gravel. Some difficulty is experienced upon the heavy lands in irrigating in the spring prior to planting, as the soil dries out very slowly and the grain can not be planted until late. Better results are obtained in such cases by watering just after the crop has been planted. The furrow method is to be preferred upon medium to heavy soils if irrigation is required at any time before the plants have attained sufficient growth to shade the ground. In case water is applied in the spring before planting, the land should be plowed, harrowed, furrowed, and irrigated. The irrigation should be followed as soon as possible by the disk harrow and the float, then by seeding. If the land has been plowed the previous fall, the disk harrow should take the place of the plow. Furrowing should follow planting for the purpose of subsequent irrigations. If the land is not to be irrigated until after the grain is planted, the land should be plowed; if not plowed the fall previous, double disked, harrowed, floated, planted, and furrowed, in the order named. In case the ground is cloddy, the roller may be used either before or after the disk.

Late summer or early fall irrigation is proving very satisfactory for destroying weeds upon foul land. When an early maturing crop like grain is grown, the land is irrigated immediately after the grain is harvested, to supply moisture with which to germinate weed or other seeds that may be in the soil. The land is plowed later in the fall and the weeds turned under; the plowing is followed later by disking and again irrigating if fall irrigation is practiced. This method of weed control is to be commended, as it not only rids the land of weeds, but affords considerable green manure.

In the Rocky Mountain States usually enough rain falls in the spring to start the grain and keep it growing until it is 6 or 8 inches high. If not, it is better to irrigate before planting rather than after. The land should be irrigated long enough before planting to allow of thorough cultivation before seeding, in order to put the soil in proper tilth. Where spring rains are common it is some times possible to irrigate in the fall or winter, and in this way store sufficient water in the soil to start the grain crop, or even bring it well along toward maturity. This can be done only on deep retentive soils. On shallow, light soils, or those with free underdrainage, it is not possible to retain much moisture throughout the winter. Irrigation before planting is not always advisable on account of delaying planting while the soil is drying out sufficiently to work well. It may then be necessary to irrigate just after planting. The danger in this is that the soil will bake and crust so that the young plants can not force their way through. If such a crust forms, it may be necessary to irrigate again to soften the crust and let the plants through, or the crust may be broken with a corrugated roller or with a peg-tooth harrow with the teeth sloping well back. The plants should be kept growing all the time and not allowed to suffer much for want of moisture. A crop which suffers for moisture or for any other reason has its vitality impaired by that much, and it is hard to restore lost vitality.

It is desirable in growing a crop for grain rather than for straw that the straw be rather short and not too rank. This is desirable for several reasons, chief of which is that it is not often possible to produce a heavy growth of fodder and of grain upon the same plant; the ranker the straw the more liability to lodging, to rust and other diseases, and usually the grain is softer and poorer in quality. Where the straw is not of importance, the first irrigation should be delayed as late as possible without impairing the vitality of the plant. The less water used in growing grain, the greater the percentage of gluten in the seed and the higher the food value. It is a good practice to withhold the first irrigation somewhat in order to obtain early ripening and a good quality of grain. There is danger of impairing the vitality, however, unless great care is taken and sound judgment used in determining when the grain begins to suffer for moisture. Grain sometimes starts a second growth if the first irrigation is left too long, and this second growth is fatal to a profitable yield. The grain plant obtains from the soil a great part of its total weight during early growth. During the intermediate growth the plant is undergoing certain changes preparatory to building up the seed. During the later growth the seed is being made chiefly from material stored in the stalk. More moisture is required during the early and later growth for these purposes than is required during the intermediate growth, and it is better to let the grain suffer a little during the early growth than during the later growth. Moisture must be present to flush the material from the stalk into the head or the grain will be shrunken, and the longer the stalk the more water will be required for this purpose. Early lack of moisture means a shorter straw, but not necessarily a small yield of grain, while a lack of moisture in the later growth means a shrunken grain with a comparatively large yield of straw. It is almost always a good rule to furnish some moisture by irrigation when the grain is in early milk to insure the flushing of the stalk.

Many natural and artificial conditions influence the time and amount of irrigation, and it is the farmer who best understands and makes use of them who is the most successful. The condition of the soil, together with the appearance of the plant, affords a practical index of the requirement of the plant for water. Soil taken from a few inches below the surface should retain its shape after having been squeezed in the hand. This test is of great value after a little practice, but frequently the inexperienced will be deceived by the heavier clay soils, as they may retain their shape and yet have very little moisture that can be obtained by the plant. An experienced farmer follows the rule upon loams, not to irrigate until the soil, which has been squeezed in the hand, as indicated above, appears barely to hold together. This test will be too close for the inexperienced.

The appearance of the plant is an excellent indication of the moisture condition where no considerable quantity of alkali is present. However, the appearance of grain when troubled with alkali, in the early stages, is somewhat similar to the appearance of grain suffering from lack of moisture. Grain which has plenty of moisture is of a light green color, and when it begins to suffer for water it turns to a darker green and the lower leaves begin to fire or turn yellow. When this condition appears water should be applied. However, it is best to anticipate this period a little, as the grain does not show its lack of moisture until some damage has been done.

If the first irrigation of grain, or the second in case it was necessary to irrigate to start the seed, occurred when the grain was in the early boot, it should be followed by an irrigation when the grain is in the late flower, and a last irrigation when the grain is in the late milk or early dough. It is not frequent that four irrigations are required if the first occurs when the grain is in the boot. However, in the localities subject to hot winds and excessive evaporation, a fourth irrigation may be necessary. Much depends upon the depth and retentiveness of the soil, but if the grain does not require irrigation until it is in late flower, there will probably be but two irrigations, the second occurring when the grain is in medium milk. Better results will usually follow three irrigations than two, although no more water is needed for the three irrigations than for the two.

The time of application will have as much and frequently more influence than the number of irrigations upon the yield and quality of grain. In the above outline of irrigations it is presumed that the spring precipitation and the moisture stored in the soil will provide for the grain until it reaches the booting stage. If irrigation water is applied immediately after planting, three irrigations will probably follow at the time indicated above.

The irrigation of grain which is rank at a late date makes the grain liable to lodge. The water softens the stalk at or near the surface of the ground, the stalk is top heavy, and a moderate or hard wind will cause the grain to topple over. This is a serious matter in windy localities, and as a result the last irrigation should not occur too late in growth. A damp growing period or too frequent irrigation tends to produce an inferior grain and to promote rust.

In growing grain for fodder, more applications of water will be given during the early growth, as the object is to secure a rank growth of straw, and the fodder is cut when the grain is in the milk. The number of irrigations for this purpose varies from one in the colder climates to twelve or fifteen in the hot, dry climate of Arizona.

QUANTITY OF WATER REQUIRED.

The quantity of water to be applied at each irrigation depends upon the number of irrigations, depth of soil, nature of subsoil, the purpose for which the grain is grown, the condition of the crop, climatic conditions, and, from a practical standpoint, the length between water turns, the available supply, method of application, the requirements of other crops, the expertness of the irrigator, and the length of time the field has been under irrigation and cultivation.

The amount of water applied to the crop for the first irrigation varies greatly. As a general rule, the soil is driest at the time of the first irrigation, and more water will be required to irrigate properly at this time than subsequently. It is always safe to assume that the ranker the growth of straw the greater will be the quantity of water required at the time the head is making. Water for irrigation is always plentiful during the early spring, but at the time the grain is filling the supply usually begins to fail. The usual practice of the farmer is to irrigate heavily in the spring and use less water as the season advances. It has been observed often that better yields have been obtained by the farmer using the least amount of water for the first irrigation when the water supply was limited for the second and third irrigations. However, if the first irrigation comes at a time when the grain is in the milk then it should be heaviest. When the first irrigation comes about the time of booting, the heavier irrigation should occur, if at all, at the second irrigation or when the grain is in the milk. On light, well-drained soils underlaid with gravel the farmer frequently applies 1 to 2 feet at each irrigation, while on the heavier and more poorly drained soils he may not be able to apply more than 4 to 6 inches. An average application for the first time will be 8 to 10 inches; at the second application 2 inches less will be the average. The third irrigation, which will occur when the water is scarce and in demand for other crops, will be lighter than either the first or second. The best result will be obtained usually with three irrigations, giving approximately 7 to 8 inches for the first and 6 inches for each of the last two irrigations. These amounts represent the water applied to the crop in the field and do not cover the loss from seepage and evaporation. The total depth of water applied to the grain crop upon the older lands will vary from 1 to 8 feet. The larger amount is used upon the more porous lands and in the warmer climates. An average depth of 2 feet will about represent the amount applied to the crop in the cooler climates and 3 feet in the warmer climates. This does not include the water lost before it reaches the farm. The losses in canals and laterals will average from 1 to 3 per cent per mile, while in gravel and loose material the losses are frequently 10 to 20 per cent per mile. These losses, together with the losses from the distributing ditches and through carelessness of the irrigator, will average at least 50 per cent. Where there are two or more canals paralleling one another and on the same side of a valley, with an uninterrupted slope between them, there may be a gain shown by the lower canal or canals through catching the seepage and waste irrigation water from above.

The amount of water required by new land is usually more than that required by older land. Very few data are available from which to judge the requirements of new land for water, but it is usual to assume that during the first two or three years 50 to 75 per cent more is required than for old land, and 20 to 25 per cent for the following two years.

The Bear River Canal in Utah affords an excellent illustration of the relative requirements of new and old lands for water. During the first few years of irrigation in this valley a second-foot of water was used upon 60 to 80 acres, and apparently the land required that amount. During the past three years, or seventeen to twenty years after the settlement of this valley, the amount of land actually served by a second-foot of water averaged for all crops 116 acres and for the grain crops 163 acres. This represents all the water the farmer actually desired to apply, as the canal company was under contract to supply a second-foot for each 80 acres. This decrease in the use of water is the result of more careful farming, a better understanding of the water requirements of the crops, a better tilth of the soil, and largely of the gradual rise of the ground-water level. Where the ground-water level was 15 to 30 feet below the surface in 1890 it can now be found within 3 to 8 feet of the surface.

What is true of the Bear River Valley is more or less true of all the older irrigated valleys. The experience has been that the ground water gradually rises with continued irrigation. The water level will be highest in the latter part of the irrigation season and in the late fall, gradually subsiding after irrigation has ceased for the season until irrigation begins the following season. In some localities the lower lands have been completely waterlogged and made worthless unless they are drained, as a result of wasteful application of water, together with seepage from canals and ditches.

The amount of water required at the source of supply under average conditions will vary with several factors, as indicated before. If it is assumed that the grain requires 2 to 3 acre-feet and this amount represents but half of the water turned into the canal, the quantity of water required at the source of supply will average 4 to 6 acre-feet per acre. This corresponds very closely to the amount found in practice. For new lands during the first few years it will be found that 50 per cent more than the above estimate may be necessary, while frequently in older sections 3 to 5 feet would be ample.

RELATION OF IRRIGATION TO RATE OF SEEDING.

In raising grain, both under irrigation and without irrigation, it has been found that the best rate of seeding depends upon the available supply of water. If there is plenty of water land should be seeded heavily, but if the water is scarce the seeding should be lighter. Experiments in Utah have demonstrated that 1 bushel of wheat to the acre is sufficient when only a moderate supply of water is used, and that when water is scarce three-fourths of a bushel of seed per acre will give larger returns than heavier seeding.

DANGER OF FAILURE.

The danger of partial failure under irrigation may be summarized as follows: The application of too much water, resulting in drowning the grain or delaying the ripening too late; the application of too little water, resulting in a shrunken grain; the application of large amounts of water at the wrong time, or the application of too light an irrigation during the filling stage. Upon heavy soils the grain may be burned or the ground may bake so hard that the grain is choked. In an area containing much alkali the alkali may be brought to the surface in large quantities and the crop destroyed, the land becoming foul to the detriment of the grain. Unfavorable meteorological conditions, such as wind, rain, hail, and frost, may cause serious injury.

VALUE OF IRRIGATED GRAIN LAND.

In the larger part of the irrigated section the water has a greater value than the land on account of there being plenty of land and a very limited water supply. The value of water and of land is very hard to determine separately. The value of improved lands and especially land devoted and planted to intensive and highly profitable crops, such as orchards, is often spoken of, yet were this land deprived of its water right it might be valueless.

The price of good grain land, including water, not suitable for beets, orchards, or other similar crops, varies from $50 to $80 per acre. Land that is adapted to more profitable crops and favorably located with regard to transportation facilities has a value of $150 to $500 per acre. In a new locality the land values would be much lower than in the older sections. Including all classes of land, it is safe to assume that the average price of land upon which grain is grown by irrigation, including the water rights, will approximate $100 per acre. Very little grain is grown upon the land of higher value or with high-priced water rights, except in rotation.

COST OF GROWING AND RETURNS.

As stated previously, the growing of grain under irrigation is not expensive farming, nor is the return great as compared with many other crops. The cost per acre will depend upon numerous local conditions, and in the following summary of cost an average of prevailing conditions is attempted. The cost of growing, exclusive of interest and taxes, varies probably not more than 30 per cent either way, while the tax and interest account will of course vary greatly, depending upon the price of land and other purely local conditions. In the estimate given below no allowance is made for fertilizers, and where this item is included it would average probably $2.25 per acre annually. The statement is divided into four parts in order that the reader may more easily grasp the cost of different operations. The statement does not provide for any part of the cost of removing natural vegetation, leveling, or preparation of the land for irrigation, other than the construction of field ditches.

There is very little difference in the farm value of wheat, oats, and barley crops per acre, and for that reason the wheat crop is taken in estimating the gross and net returns per acre. The yield of wheat will vary, with the natural conditions and with the intelligence and industry of the grower, from 30 to 60 bushels per acre. It is not advisable, however, to take the yields obtained by the careless, indifferent farmer as a basis, and eliminating this class of farmers, the yield will average at least 40 bushels per acre. The price per bushel of wheat is taken at 75.1 cents and corresponds with the average farm prices for ten years, ending with 1907. This price varies from year to year and therefore the income is subject to market prices of the different grains.

Cost of growing grain per acre.

Culture:		
Plowing	$2.00	
Harrowing and leveling	.90	
Seed	1.10	
Seeding	.50	
Ditching	.15	
Irrigating	1.25	
		$5.90
Harvesting:		
Cutting with binder	1.00	
Twine for binding	.50	
Shocking	.40	
Hauling	1.25	
Thrashing	2.50	
		5.65
Marketing: Hauling to local market or to cars		.75
Interest and taxes:		
Water tax	.50	
Tax on land	.30	
Interest on farm equipment	.25	
Interest on $100, at 8 per cent	8.00	
		9.05
Total		21.35
Gross returns:		
Forty bushels wheat, at 75.1 cents per bushel		30.40
Net		9.05

The above statement of cost and return gives a net profit of $9.05 per acre under favorable conditions, with average good farming. One advantage of growing grain for a farmer with very little ready money is the small cash outlay required upon comparatively large farms. The items requiring cash outlay are usually seed, twine, thrashing, water tax, and taxes on land, or approximately $4.90 per acre. Of this amount probably not more than $1.10 per acre for seed would be required before thrashing. The crop can be grown and harvested, without mortgaging, for a cash outlay of not more than $1.60 per acre, not including the original investment for land and equipment. Thus a farmer with the average-sized family can cultivate a large area with a very small cash capital.

Grain is essentially a crop for the farmer with a very limited capital or for the farmer on new land. It is not advisable, however, to grow many crops of grain in succession on new land, as the yields fall off rapidly. The land should be seeded to alfalfa, and grain used only in rotation after the first year or two. It is not a crop for revenue upon small farms nor where intensive farming is practiced.

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FARMERS' BULLETIN 400.

A MORE PROFITABLE CORN-PLANTING METHOD.

BY

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1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 1, 1910.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "A More Profitable Corn-Planting Method," by C. P. Hartley, Physiologist in Charge of Corn Investigations.

Studies of the habits of growth both below and above ground of this our most valuable and widely grown plant have for several years indicated that fields of checked corn, comprising about half of the total corn acreage, yield less than they would if the kernels were not crowded so closely together in the hills.

As this assumption has now been substantiated, the farmers should be informed on the subject and advised to substitute, as soon as possible, some method of checking that will give every stalk in their cornfields a fair chance to thrive and produce abundantly.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—571.

A MORE PROFITABLE CORN-PLANTING METHOD.

INTRODUCTION.

Much study has been given to corn-planting methods and much progress made. This progress has usually been along the line of more rapid and easier planting and cultivating. While retaining these advantages, the method here described causes higher yields by supplying each plant with better conditions for growth and production.

METHODS BY WHICH MOST CORN IS PLANTED.

Single-row corn planters drawn by one horse—or two-row planters drawn by two horses—are used in planting the greater part of the corn grown in the United States. All these planters deposit the kernels of hill-planted corn together in a small space, or bunch, resulting in the stunting of many plants because of insufficient space to form a strong root system or vigorous stalk and leaves. Many prevent this stunting by drilling their corn. Drilled corn is planted in rows, one kernel in a place. Checked corn is planted in hills that permit cultivation both ways.

Which is the most profitable, drilling or checking, is a much debated question. On hilly land, where the soil washes readily, checking is not practicable. Where both methods are practicable one method has about as many advantages and disadvantages as the other, and corn producers are practicing the two methods to about the same extent.

THE ADVANTAGE OF DRILLING.

Standing singly, as in drilled corn, each plant has a fairer chance both below ground and above ground to develop normally and produce well.

It requires a little less care to drill than to check, though in fields free from trees the difference is very slight after the operator has become accustomed to the use of the checking wire which is stretched across the field.

THE ADVANTAGE OF CHECKING.

Checking enables the corn to be cross-cultivated and kept free from weeds and the entire soil surface kept in good condition without the expensive labor of hoeing.

DOUBLE ADVANTAGES OF KERNEL-SPACED CHECKING.

"Kernel-spaced checking" is the term used to designate the more profitable method described in this bulletin. It largely overcomes the disadvantages and combines the advantages of the two methods now used in planting most of the corn grown in the United States.

The double advantages of kernel-spaced checking became apparent several years ago in connection with tests of thick planting on very fertile river-bottom soil. On this soil one stalk to every 12 inches of row, when hoed, was found to give higher yields than checked corn with either three or four stalks in every hill.

Drilling, however, was not practicable because of the abundant growth of weeds. Planting four stalks in each hill with a check-rower was found to result in an unusually large percentage of nubbins and stunted and barren stalks. Drilled corn with the same number of stalks to the acre gave larger yields with fewer nubbins and stunted and barren stalks, but could not be well cultivated without expensive hoeing.

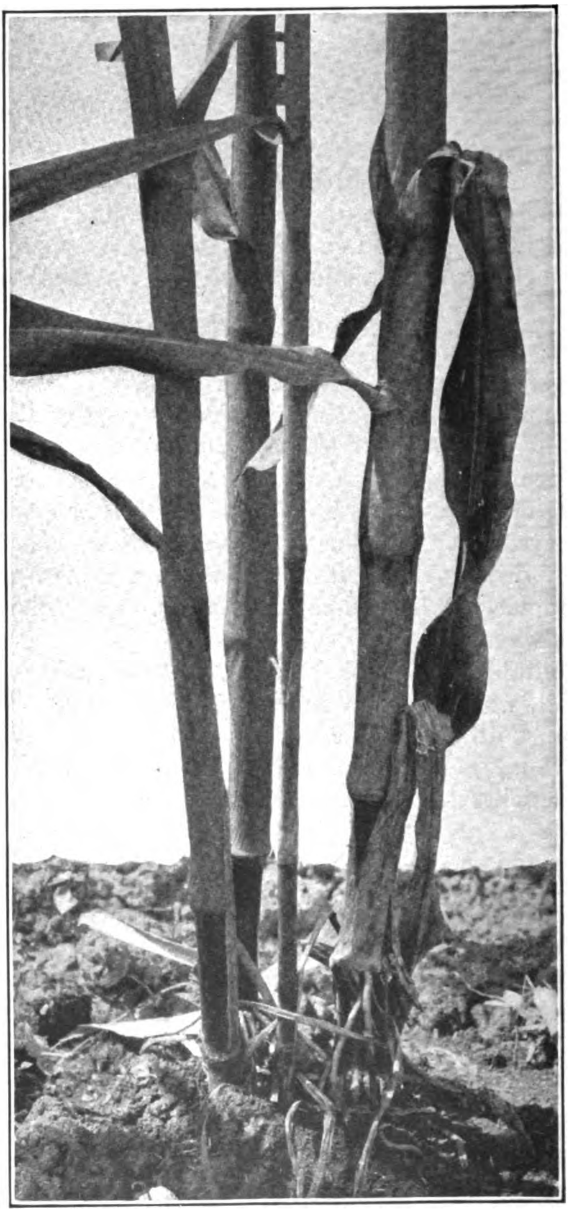

FIG. 1.—Hill of corn planted by a modern check-rower. The central stalk had no chance to develop, either below or above ground, and produced but a nubbin.

It was thought that kernel-spaced checking would be found profitable on soil sufficiently well supplied with moisture and fertility to permit four or five stalks to the hill. This has been found to be the case. Furthermore, it has been found profitable on dry soils of medium fertility.

In all fields of corn planted with our most modern check-rowers can be found many hills containing a stalk that has not produced well. In many such cases the stunting is due to the quicker starting or better location of the other plants, which enabled them to monopolize the space, moisture, fertility, and sunlight of the limited area in which the kernels were planted. (See fig. 1.)

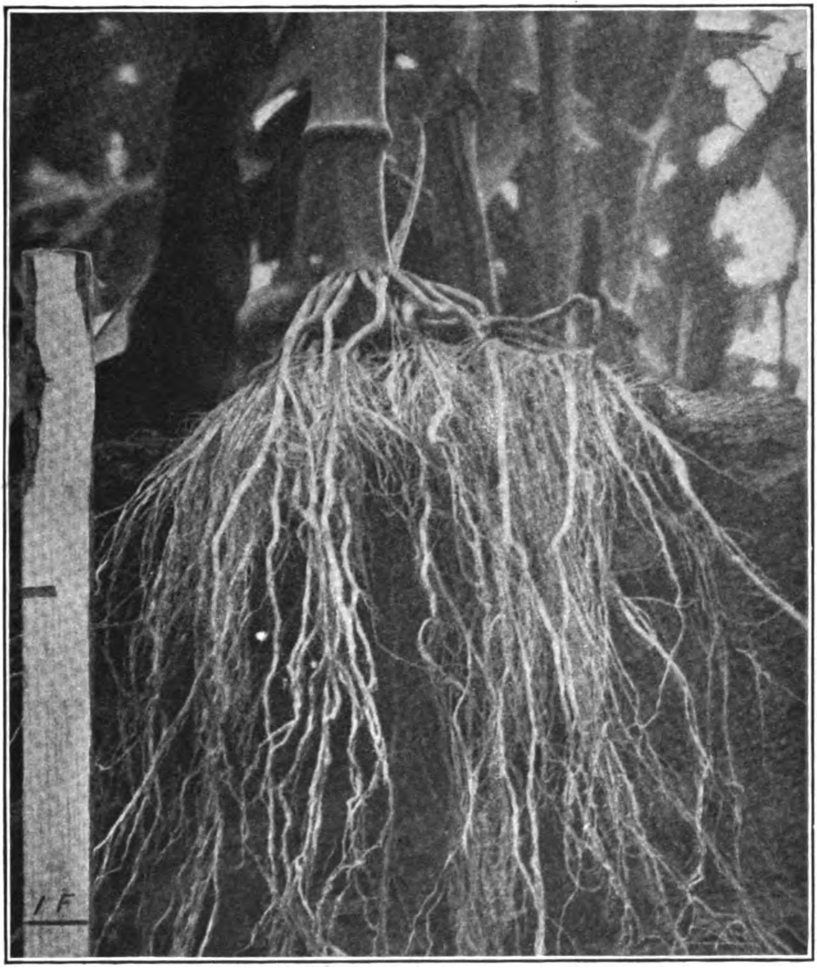

FIG. 2.—Base of a corn plant at silking time. For a foothold each plant needs a cubic foot of space.

With roots and stalks limited to so small a space, plants from any cause once obtaining a monopoly easily retain it. This plausible idea is substantiated by the tests described later, which produced more stunted and barren stalks and more nubbins in rows of ordinary checking than in adjacent rows of kernel-spaced checking.

Such stunting, because of the nature of the corn plant, materially reduces the grain yield. Plants that are crowded to such an extent that they become slender and scarcely more than half their normal height are either barren or produce only nubbins.

WHY KERNEL-SPACED CHECKING SHOULD GIVE INCREASED YIELDS.

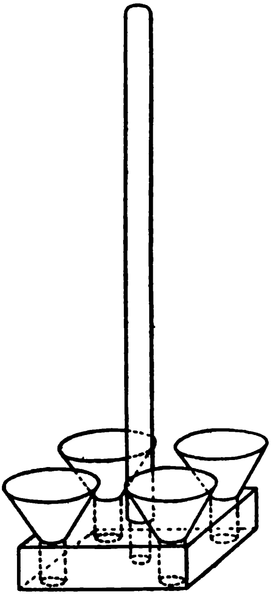

FIG. 3.—The device used in dropping corn by hand in the kernel-spaced rows of the tests.

The disadvantage under which the two or more plants of a hill are compelled to grow by the kernels having been bunched together is so plain that it is remarkable we have not long ago devised a method of checking corn that gives each plant room to form a normal root system.

For a distance of 6 inches in every direction from the base of a normal corn plant the soil is crowded entirely full of roots. When several kernels are bunched together the roots of all the stalks of the hill are so matted together that the pulling of one stalk pulls out the entire hill, and the pressure of wind upon all the stalks is more likely to blow over the entire hill than when the stalks stand several inches apart in the hill, thus forming a broader base of support. Figure 2 shows the base of one corn plant at silking time, the critical period, when all the roots should be well located for supplying moisture to the plant. The three stalks of a hill grow at a great disadvantage with no more foothold in the soil than one plant requires.

KERNEL-SPACED CHECKING TESTED IN COMPARISON WITH THE USUAL METHOD.

The following-described tests were especially planned to decide whether the kernel spacing of checked corn would increase the yield above that obtained by the generally practiced method of checking. Eight alternating rows of kernel-spaced and of ordinary checking were planted in three different localities on different types of soil. In order to test the practicability of cultivating the kernel-spaced checking, the test rows were placed in the center of fields of checked corn and were without difficulty cultivated both ways when the fields were cultivated.

The device used for space planting is shown in figure 3. Two kernels were planted at each corner of a 5-inch square. Each space-planted row was followed by a row treated in all respects the same except that the kernels were not so well separated, being deposited as a check-rower would deposit them and with six kernels to the hill.

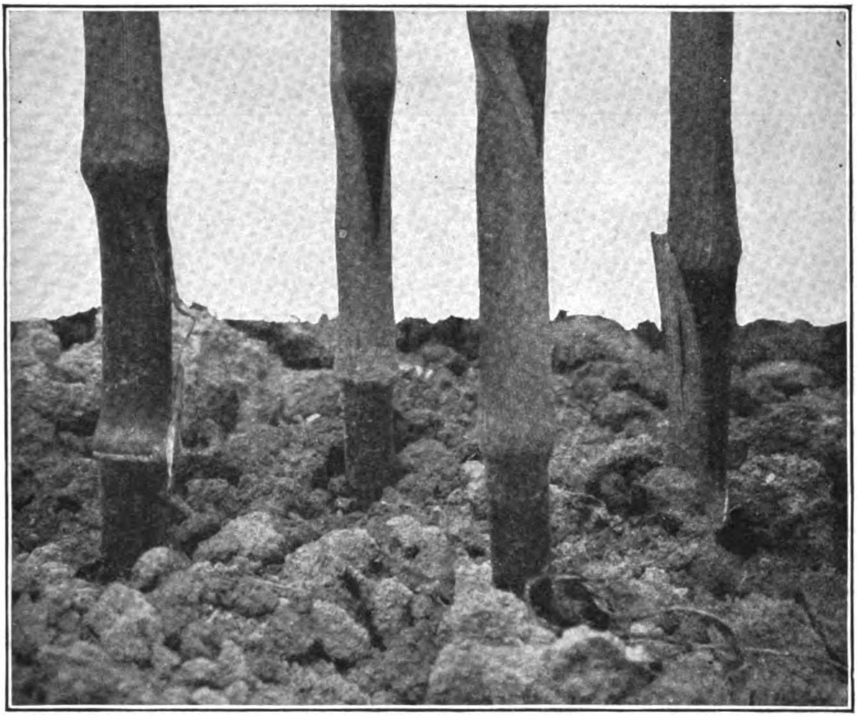

FIG. 4.—A hill of the kernel-spaced rows of the tests. The stalks stand at the corners of a 5-inch square. (Photographed before the formation of brace roots at the lower nodes.)

When the corn was a foot tall, all the rows were thinned to a uniform stand. Four stalks to the hill were retained wherever possible. When about ready to tassel several more stalks were removed from some of the rows to bring adjacent rows to exactly the same number of stalks.

Figures 4 and 5 show the differences in appearance due to the different methods of

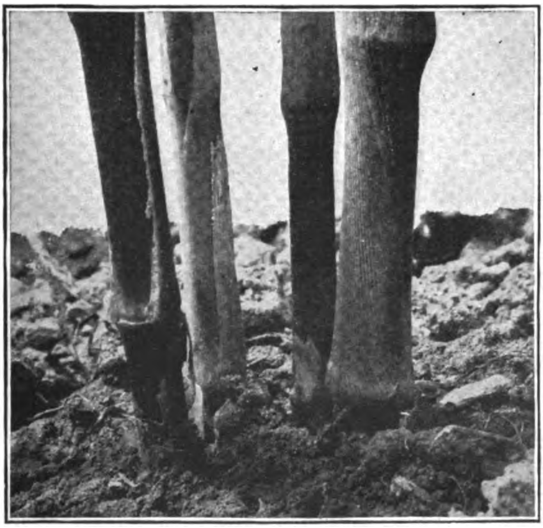

FIG. 5.—A hill of the rows tested in alternation with the kernel-spaced rows. These hills were bunched to no greater extent than is done by the modern check-rower. (See fig. 1.)

planting. Figure 4 shows a typical hill from the space-planted rows, while figure 5 is typical of the usual method of checking. The difference in the uniformity of the stalks is very marked.

TABLE I.—*Comparative yields of corn when kernel-spaced checking and the usual method of checking were employed.*

	Tests at Round Hill, Va.	Tests at Piketon, Ohio.	Tests at McLean, Va.
Character of the summer	Very dry	Very favorable	Very dry.
Nature of the soil.	Stony clay loam.	River-bottom deposit.	Heavy clay loam
Distances between corn hills	3¾ by 3⅓ feet.	3⅓ by 3¼ feet	3¾ by 3½ feet.
Height of the varieties tested	Tall	Very tall	Medium.
Average number of stalks to the hill.	3	3¾	3⅘.
Number of stalks to the acre	10,500	15,100	12,700.
Stalk circumference increased by spacing.	14½ per cent.	7 per cent	13 per cent.
Number of poor ears produced:			
Kernel-spaced method	498	447	652.
Usual method	584	502	712.
Yield per acre:			
Kernel-spaced method	55 bushels	118½ bushels	64 bushels.
Usual method	53 bushels	114 bushels	61 bushels.
Gain to the acre by spacing the kernels.	2 bushels	4½ bushels	3 bushels.
Number of adjacent-row tests	7	9	9.
Number of times in which adjacent-row tests produced equally.	0	1	1.
Number of tests in which kernel spacing increased the yields.	4	7	8.
Increase obtained by spacing the kernels.	3¾ per cent	4 per cent	5 per cent.

KERNEL-SPACED CHECKING YIELDS BETTER IN EVERY CASE.

Under the different conditions of climate and soil and with different varieties of corn, each test has shown that kernel spacing of checked corn increases the yield. The kernels were placed only 5 inches apart in the hills. A distance of 8 or 10 inches may increase the yield still more, and such hills can be readily cultivated both ways provided the checking is accurately done. Check-rowers can be manufactured with two shoes for each corn row and a separate dropping tube for each kernel of a hill. They can be made adjustable, so that the number of kernels dropped and the spacing distances between the kernels of a hill can be suited to the fertility of the soil and the variety of corn planted.

Proper distances for spacing the kernels within the hill will have to be determined for large and small growing varieties. The three varieties tested ranged from medium to very tall, each being adapted to the locality in which it was tested. All produced better by spacing the kernels of each hill 5 inches apart than by the customary method of dropping them close together in the hill.

In addition to the 25 tests of rows growing side by side in which one row was kernel-spaced and the adjacent row checked by the usual method, there were at each locality two adjacent plats, one kernel-spaced checked and the other checked by the usual method. At two of the localities the yield of the kernel-spaced plats exceeded that of those planted by the usual method to about the same extent as in the alternate-row tests. At McLean, Va., the plats produced equally well, but the alternate-row plantings gave an increase of 11 per cent in yield due to kernel spacing, bringing the average increase for the two methods of testing to practically 5 per cent, as given in the table.

THE INCREASED YIELD IS NET GAIN.

Two bushels more to the acre, or a 4 per cent increase, is not small enough to be ignored, especially when obtainable without cost except the initial cost of a kernel-spacing check-rower.

Increased yields resulting from applications of expensive fertilizers sometimes fail to increase the profit on the crop. The increased yield due to spacing the kernels is clear gain, since a properly constructed check-rower can drop the seed in separate places as rapidly and as cheaply as the present check-rower bunches them.

In planting 50 acres of corn such a check-rower would pay for itself the first year. In planting 100 acres, estimating the production at the average of 26 bushels, it would return a net profit of 104 bushels.

A 4 per cent increase in the value of the corn crop of Illinois for one year would amount to $6,000,000. About one-half of the corn acreage of the United States is checked or planted with planters that drop all the kernels of a hill in a bunch. The substitution of kernel-spacing planters would add 50,000,000 bushels of corn to our annual production.

KERNEL-SPACED CHECKING PERMITS CULTIVATION WITHOUT DIFFICULTY.

The 5-inch spacing of the kernels in each hill did not make it difficult to properly cultivate in both directions with 2-horse double cultivators, although in one instance the rows were but 3⅓ feet apart in one direction and 3¼ feet in the other. Three-horse 2-row cultivators could have been used to as good advantage as in the usual method of checking. If the kernels in each hill are spaced 6 or 8 inches apart, the gangs of shovels on the cultivator will need to be set farther apart in order to properly straddle the hills. A spacing wider than 8 inches may allow weeds to grow in the corn hills. In this respect the 5-inch kernel spacing gave no greater growth of weeds and received no more work than the ordinary checking.

OTHER ADVANTAGES OF KERNEL SPACING.

Increased yield without extra cost is abundant reason to cause a change of methods. A few other advantages of kernel spacing may be mentioned. It is easier to thin kernel-spaced hills, and the thinning can be done without injury to the remaining stalks.

When the plants stand separately in the hills, an entire hill is less liable to be pulled out by the harrow, the weeder, or the cultivator. The entire hill is not so likely to be injured by accident, disease, cutworms, or corn-root insects. The better distribution not only affords each stalk better sunlight, but also shades the soil better, thereby lessening evaporation from the heated soil during the summer months.

At McLean, Va., the rows checked by the usual method blew down at tasseling time to a much greater extent than the adjacent kernel-spaced rows. At Piketon, Ohio, the kernel-spaced rows were noticed at harvest time to have fewer down hills than the adjacent bunch-planted rows. The kernel-spaced stalks appeared stronger and measurements proved them to be at each locality of greater circumference than the bunch-planted stalks. (See Table I.)

PRESENT APPLICATION OF THE ADVANTAGES.

Until kernel-spacing check-rowers are placed upon the market farmers can utilize this method extensively only by remodeling their check-rowers or by double driving. By returning across the field with the check-rower, without resetting the wire, and driving 6 inches from the previous track, each hill can be made up of two bunches of kernels. This will improve somewhat the distribution of the plants in the hills, but will not be as good as a check-rower with four or more dropping tubes for each corn row.

By double driving, as just mentioned, with planters set to drop one kernel at a time, each stalk will be given room to form a good root system. Drilled corn planted by this method won the Iowa sweepstakes prize in 1909 by producing 153 bushels of shelled corn on 1 acre.[a]

PROFIT DEPENDS MAINLY ON LARGE YIELDS TO THE ACRE.

Increasing population and increasing value of land are sure to stop the long-continued practice of planting corn thinner as the land becomes poorer, making up the supply by planting more acres. Our future increase in corn production must be accomplished mainly by filling the soil with water-absorbing and water-holding humus, accompanied by thicker planting. This practice has produced 239 bushels of shelled corn on an acre in South Carolina,[b] and 226 bushels on an acre in North Carolina.[c]

Soils are not impoverished by producing large crops. On the contrary, the larger the crops and the more frequently they are produced the better the opportunity to enrich the soil by plowing under a sufficient portion of the vegetable matter produced. The soil should be kept busy enriching itself through the decay of vegetation, as forest lands enrich themselves. To most soils one or more mineral elements must eventually be applied to replace those which are removed from the farm in the form of grain or animal products.

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[a] See Farmers' Tribune, February 3, 1910. John Sundberg, of Monona County, Iowa, won this prize in accordance with the rules of the Iowa Corn Growers' Association. The planter was driven the second time several inches from its previous track, giving a double row of plants. Adjusted to drop one kernel every 16 inches the planter driven in this manner planted 20,633 kernels to the acre. The acre had been a clover pasture for five years and was fall-plowed. No manure or commercial fertilizer was used.

[b] See C. S. Plumb's book on Indian Corn Culture, 1895, p. 220. The rows were alternately 3 and 6 feet apart, and 5 or 6 kernels were dropped to each foot of the row, 1,000 bushels of stable manure, 600 bushels of cotton seed, and $50 worth of commercial fertilizer being applied to the acre.

[c] See Wake County Corn Experiments of 1909, by F. A. Olds, secretary, Chamber of Commerce, Raleigh, N. C. The first prize was won by J. F. Batts, of Garner, N. C. The rows were 41 inches apart, and 3 kernels were planted in hills 8 inches apart in the row, 19,000 stalks being grown on 1 acre. Forty-five 2-horse loads of manure and $59 worth of commercial fertilizer were applied to the acre.

SUMMARY.

In planting corn in hills practically all corn planters drop all the kernels of the hill in a bunch.

A study of the best conditions for growth and production indicates that bunch planting results in unnecessary crowding both above and below the ground, weakening the stalks and reducing the yield.

Kernel-spaced checking combines the advantages and overcomes the disadvantages of drilling and checking, the two methods by which nearly all corn is now planted.

Tests with three varieties of corn under different conditions of soil and climate in every case gave increased yields due wholly to a separation of the kernels planted in each hill.

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